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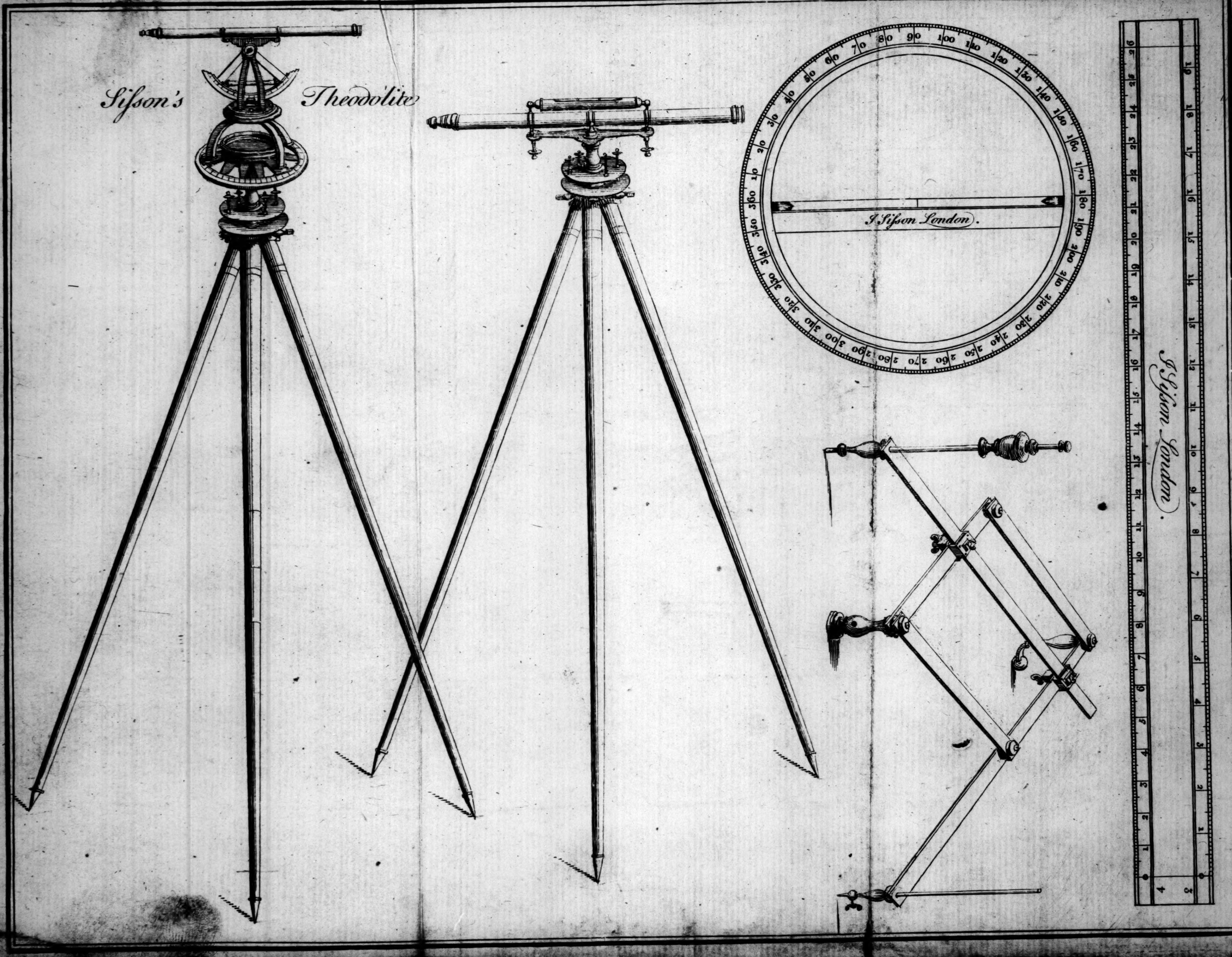

Siſson's Theodolite

W, S
K

THE
Practical Surveyor,
OR, THE
Art of *Land-Meaſuring*,
Made EASY.

Shewing by plain and practical Rules, how to Survey any Piece of Land whatſoever, by the Plain-Table, Theodolite, or Circumferentor: Or, by the Chain only. And how to Protract, Caſt up, Reduce, and Divide the ſame.

LIKEWISE

How to Protract Obſervations made with the Needle; and how to Caſt up the Content of any Plott of Land: By Methods more Exact and Expeditious than heretofore uſed.

To which is added,

An APPENDIX,

Shewing how to Draw the Plan of Buildings, *&c.* in Perſpective, from Obſervations made by the Theodolite. As alſo the Uſe of a new-invented *Spirit-Level.* With ſeveral other Things never before made Publick.

Socrates, *hunc finem Geometriæ Principalem eſſe ſtatuebat*; *Ut agrum planum metire dividereq; poſſit.*
Pitiſcus Geod.

LONDON:
Printed for J. HOOKE, at the *Flower-de-luce* againſt St. *Dunſtan*'s Church in *Fleet-ſtreet*: And J. SISSON, Mathematical Inſtrument-maker, the Corner of *Beaufort-Buildings* in the *Strand.* M,DCC,XXV.

BRITISH MUSEUM

THE PREFACE TO THE READER.

IN this ſmall Tract you'll find the whole Art of Surveying Land Epitomized: The Rules and Methods here laid down in a plain and familiar Manner, being ſuch as are fitteſt for a Practiſer's Uſe, without an unneceſſary Mixture of uſeleſs Curioſities and needleſs Repetitions. And altho' Brevity be chiefly intended, yet nothing is here omitted, but what might well enough be ſpared in a Treatiſe that immediately relates to Practice.

I know the common Objection will be raiſed by the Ignorant; that is, What needs any more Writing in this Kind, ſince ſo many Authors have, with great Ingenuity, beſtowed no ſmall Pains therein; (to whoſe Labours and Induſtry I acknowledge this Tract not a little beholding.) Now to this Objection, the old and common Anſwer muſt be returned, That *A Pigmy mounted on the Shoulders of a Giant, may ſee further than its Supporter*. And Arts Mathematical can never be ſo fully learned, but that there will ſtill be new Experiments left for the Trial of others that ſucceed.

Beſides, here are inſerted, not only the moſt uſeful and Practical Methods yet extant in any other Author, but alſo a great many new Improvements never before made publick, rendring the Buſineſs of Surveying Land more exact, eaſy and expeditious.

The Book is divided into Seven Chapters, and the Appendix into Three, and theſe into ſeveral Sections, for the more orderly Ranging the ſeveral Subjects under their proper Heads.

In the Firſt and Second Chapters, is deſcribed the Manner of Meaſuring Land by the moſt uſeful Inſtruments, the Plain Table, Theodolite and Circumferentor; the firſt being proper for Gardens, or ſuch ſmall Pieces of Land about Buildings, the ſecond for larger Tracts of encloſed Land, and the third for Parks, Commons, *&c.*

In Handling this, I have not choſe the moſt Accurate Method I could think of, but rather the moſt Plain and Simple, as being moſt Agreeable to the Conception of a Stranger to the Art, to whom nothing can be too plain.

In the Third Chapter, is deſcribed a new Way of Protracting Obſervations made in the Field, by the Needle: As alſo how to Caſt up the Content of a Piece of Land, by Methods more facile and expeditious than heretofore uſed.

In the Fourth, the Uſe of the Theodolite is ſhewn in Surveying ſeveral Parcels of Land lying together; with the Form of the Field-Book, and Plan of the Work annexed; which ſhews, by Inſpection only, the ſeveral Stations and Station-Lines throughout the whole; from which the Obſervations are made in the Field.

The Fifth ſhews how to meaſure or plot any Piece of Land by the Chain only, without the Help of any other Inſtrument in the Field but a ſmall Croſs.

The Sixth ſhews the Manner of Laying-out, and Dividing Land, without inſerting the various Methods by which the ſame might be performed; but by ſuch only as are the moſt eaſy and fit for Practice.

The Seventh ſhews how a County is to be Surveyed; as alſo Roads and Rivers; and how to make the Ground-Plott of a City, *&c.* And becauſe theſe more ſeldom come in Practice, I only touched generally on the Manner how they are to be performed.

In the Appendix is deſcribed the Uſe of a new Spirit-Level, for Conveying Water to any appointed Place: Shewing alſo, how the Draught of a Building or other Objects, may be drawn in Perſpective, from Obſervations made with the Theodolite, by a Method entirely new: As alſo how to find a true Meridian-Line, *&c.* Theſe Problems, tho' not immediately related to the Buſineſs of Land-meaſuring, will be found very uſeful to a Practitioner in that Art, and may well deſerve the little Room that is allotted them in this Book.

It may be expected, here ſhould have been inſerted (as uſual in Books of Surveying) more *Theorems*, *&c.* of Geometry; I confeſs it is neceſſary a Surveyor ſhould be well acquainted therewith, as alſo with Trigonometry, as the Ground-work of the reſt. But then he may as well read in the Commentators on *Euclid*, the Demonſtration of each Theorem at large (beginning with the Principles of the Art firſt) as to ſee 'em tranſcribed by Piecemeal any where elſe. Since the Two Theorems in the Firſt Chapter, well underſtood and applied, will be ſufficient for the Performance of moſt Problems relating to Land-meaſuring: And indeed, a Perſon who is well acquainted with the Uſe of his Inſtruments, will have little Occaſion to have Recourſe to Trigonometrical Calculations for finding his Angles, and for caſting up the Content of any Piece of Land after the Plott thereof is made; the Directions in Sect. 4. may be ſufficient: But if any one thinks otherwiſe, he may be farther informed from the Works of our Trigonometrical Writers, of which there are many good ones extant.

However, 'tis hop'd, the Country Farmer, who underſtands but ſo much of Arithmetick, as to add, ſubtract, multiply and divide (with a little Practice, the genuine Parent of Perfection) by theſe plain Directions, and with good Inſtruments; will be enabled to find the Content of each Piece of Land in his own Occupation, (and thoſe who will not be at the Charge of Inſtruments, may make good Uſe of the Fifth Chapter,) and that this Knowledge is extremely neceſſary to the Countryman, none but the groſsly ignorant will deny, ſince thereby he may judge what Stock of Cattle each Field will be likely to feed, or what Quantity of Seed will be ſufficient for each Acre, or what Number of Workmen to reap or mow the ſame, *&c.* Which makes me admire, when I reflect, that this Science ſo beneficial to the Publick, as well as particular Perſons, ſhould be ſo much neglected, being ſo plain and obvious to every Capacity.

But I ſhall forbear any Panegyrical Expreſſions in Praiſe of the Art it ſelf, (tho' much might be ſaid on that Head) on Account of its Antiquity, Salubrity, Pleaſantneſs, and above all, its Uſefulneſs, *Ornari res ipſa negat contenta doceri.*

As for the Book it ſelf, tho' perhaps ſome ill-natur'd Artiſts may be offended therewith, becauſe ſeveral Things herein are diſcovered, (which they would have been as well pleaſed ſhould have been concealed) like Flowers gathered and placed in one Garland, and proſtituted to every one's View; yet if it proves any way uſeful to thoſe for whom it was deſigned, I have my End in Publiſhing it. *Rumpatur quiſquis rumpitur invidiâ.*

Indeed I hoped ſome Perſon who had more Hours of Leiſure to ſpare than my ſelf, might have ſpent ſome of them in Compoſing ſomething of this Nature, ſince all the Books I have yet ſeen are much deficient in many of the moſt neceſſary Parts of the Buſineſs, or elſe too voluminous for common Uſe; but could not hear of any ſuch, till this was in the Preſs, and ſeveral Sheets wrought off, elſe I ſhould gladly have reſigned the Task: But now that it is printed, e'en let it be publiſhed; and at the Bookſeller's Requeſt, I have added thus much by Way of Preface, which I ſhall conclude with a Saying I have ſomewhere met with, *Va*, *mon Enfant*, *prend ta Fortune.*

S. W.

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ADVERTISEMENT.

BECAUSE the Practice of SURVEYING depends much on the *Inſtruments* uſed therein, which, being ill-contrived and adjuſted, cauſe unavoidable Errors: Therefore I thought fit to ſay, That all Sorts of Inſtruments for Surveying Land, are made with the greateſt Accuracy and neweſt Improvements,

By JONATHAN SISSON,

Mathematical Inſtrument-Maker,

At the Corner of *Beaufort-Buildings,*
In the *Strand,* *LONDON:*

He being the *Only Perſon* that makes the *Theodolite,* *Spirit-Level,* and *Parallelogram,* hereafter mention'd. Where alſo any Gentlemen or Others may be furniſh'd with Sun-Dials of all Sizes, to be fix'd for particular Latitudes, or portable and univerſal ones, Double Horizontal Dials, and Projections on the Plane of any Circle, Mr. *Collins*'s Quadrants in Braſs, Twelve or Six Inches Radius, Spheres of all Sorts, and Globes, the beſt Extant: With all other Mathematical Inſtruments, both for Sea and Land, made in Silver, Braſs, Ivory or Wood: And Sold at Reaſonable Rates.

THE
Practical SURVEYOR:

CHAP. I.

Shewing how to make a Plott of a Piece of Land by the Plain Table, and caſt up the Content thereof.

SECT. I.

A Geometrical Superficies or Surface, is produc'd or form'd by the Motion of a Line, as that is deſcrib'd by the Motion of a Point, for if *a b*, in *Fig.* 1. be equally mov'd upon the ſame Plane to *c d*, then will the Points at *a* and *b*, deſcribe the two Lines *a c*, and *b d*; and by ſo doing, they will generate the Superficies or Figure *a b c d*, being the Quantity of two Dimenſions, *viz.* it hath Length and Breadth (but not Thickneſs,) conſequently the Bounds or Limits of a Superficies are Lines; ſo if the Line *a b*, doth contain in Length five Chains, and the Line *a c* two Chains, and if their oppoſite Sides and Angles be equal, the Quantity of Land theſe four Lines encloſe, *viz.* (*a b*, *b d*, *d c*, and *c a*,) will be an Acre.

Our preſent Buſineſs therefore, will be to compute what Number of ſuch Acres, or Parts of an Acre, are contain'd in any Piece of Land, (be it Arable, Meadow or Woodland) whoſe Extent is limitted by certain Lines or Bounders. Now an Acre of Land (by the Statute of 33. *of Ed.* I.) is appointed to contain 160 ſquare Perches or Poles; it is no matter in what Form it lyes, ſo it contains 160 ſquare Poles; and *Gunter's* Chain (the beſt for Practice) being therefore made four Pole long, ten of theſe ſquare Chains make an Acre, (that is to ſay) one Chain in Breadth, and ten in Length, or two in Breadth, and five in Length, *&c.* do contain 160 ſquare Poles, as *per* Statute. See the following Tables.

1 *Table of long Meaſure.*

Inches	*Link*	*Foot*	*Yard*	*Perch*	*Chain*	*Mile*
Inches	7. 92	12	36	198	792	63360
	Links	1. 515	4 .56	25	100	8000
		Feet	3	16. 5	66	5280
			Yard	5. 5	22	1760
				Perch	4	320
					Chain	80

Length of an Acre	*Breadth an Acre*		
Chains	*Chains*	*Links*	*Pts. of a Link*
1	10	00	
2	5	00	
3	3	33	333
4	2	50	
5	2	00	
6	1	66	666
7	1	42	285
8	1	25	
9	1	11	111

A Table

A Table of ſquare Meaſure.

	Inch	*Links*	*Feet*	*Yards*	*Poles*	*Chains*	*Acre*
Inch	1						
Links	62726	1					
Feet	144	2295	1				
Yards	1296	20755	9	1			
Poles	39204	625	27225	30. 25	1		
Chains	627264	10000	4356	484	16	1	
Acre	6272640	100000	43560	4840	160	10	1

A Table, ſhewing how many Chains, Links, and Parts, are contain'd in any Number of Feet, from 1 *to* 10000.

Feet	*Chain*	*Links*	*Pts. of Links*	*Feet*	*Chain*	*Links*	*Pts. of Links*
1	0	1	515	200	3	03	030
2	0	3	030	300	4	54	545
3	0	4	545	400	6	06	060
4	0	6	060	500	7	57	575
5	0	7	575				
6	0	9	090	600	9	09	090
7	0	10	606	700	10	60	606
8	0	12	121	800	12	12	121
9	0	13	636	900	13	63	636
10	0	15	151	1000	15	15	151
20	0	30	303	2000	30	30	303
30	0	45	454	3000	45	45	454
40	0	60	606	4000	60	60	606
50	0	75	757	5000	75	7	757
60	0	90	909	6000	90	90	909
70	1	06	060	7000	106	06	060
80	1	21	212	8000	121	21	212
90	1	36	363	9000	136	36	360
100	1	51	515	10000	151	51	515

The Uſe of theſe Tables is plain by Inſpection, therefore particular Directions are needleſs.

Let Figure 2 be ſuppos'd to repreſent a Piece of Land, bounded with the four ſtrait Lines *a b*, *b d*, *d c*, and *c a*, whoſe Lengths are each ten Chain, then the Area or Superficies thereof will contain ten times ten ſquare Chains, or ten Acres, (as *per Fig.*) each of the ſmall Squares repreſenting one ſquare Chain.

But before the Plan of any Piece of Land can be laid down (or protracted) on Paper, in order to make a Computation of the Area or Quantity of Superficies it contains, 'tis neceſſary we ſhould know the Length and Poſition of the ſeveral Lines that bound the ſame.

And to find the Length and Poſition of Lines in the Field, we make uſe of Inſtruments, *viz.*

To meaſure the Length of Lines in the Field, we uſe *Gunter*'s Chain, containing in Length four Poles or 66 Feet, divided into 100 Parts or Links, each Link being 7 Inches, and $\frac{92}{100}$ of an Inch, and a Staff whoſe Length is equal to $\frac{1}{10}$ part of the Chain; that is to ſay, 10 Links, or 6 Foot 7 Inches $\frac{2}{10}$ of an Inch. For Roads the Wheel.

Inſtruments us'd for taking the Poſition of Lines, are of two Kinds. With ſome we take the Poſition of a Line by the Angle which it makes with the Meridian, uſing a Box and Needle, as the Circumferentor, *&c.* and this is uſually call'd the Bearing of the Line.

With others we take the Poſition by the Angle that the Line makes with any other given in Poſition; as with the Limb of the Theodolite, the Chain, *&c.*

But with ſome we take the Angle it ſelf as with the Plain Table, *&c.*

All other Inſtruments either differ from theſe only in Name, or are contain'd in them.

The Inſtruments for Plotting, are a Scale and Compaſſes, or rather a Scale decimally divided cloſe to the Edge, and at every tenth Diviſion, numbred 0, 1, 2, 3, *&c.* denoting Chains, and a Protractor always to be divided, numbred, and fitted to the Inſtrument.

Of the uſe of theſe ſeveral Inſtruments in their Order; and firſt of the Plain Table; the Uſes thereof being as plain as the Name of the Inſtrument denotes.

But becauſe we make uſe of the Chain in all manner of Buſineſs in the Field, it will be neceſſary, in the firſt place, to inform our ſelves in the manner how to manage it in meaſuring the Length of Lines in the Field.

SECT. II.

Directions for meaſuring with the Chain.

The Chain contains in Length 4 Pole or *66* Feet, divided into 100 Links, each Link being $7\frac{92}{100}$ Inches, as aforeſaid, having a large Ring exactly in the middle of the Chain, and pretty large Pieces of Braſs of different Shapes at the end of each 10 Links, for the ſpeedier counting of the odd Links; alſo you may tie a large red Rag at 50 Links, and others of a lighter Colour at 25, from each end of the Chain, eſpecially when the Graſs is long.

Take care that they who carry the Chain deviate not from a ſtrait Line, (that being the neareſt Diſtance that can be between any two Places,) for if the Lines be not exactly meaſured, neither the Form nor Content of the Plott can be true. Provide a Staff juſt ſix Foot ſeven Inches and $\frac{2}{10}$ long, which divide into 10 equal Parts, ſo will the Whole be the Length of 10 Links, and each Part the Length of one Link, and 10 times the Length of this Staff (which you may call the off-ſet Staff) the Length of the whole Chain; alſo provide 9 Arrows or ſmall Sticks above a Foot long, which you may mark at the Tops with Bits of red Cloath, and at the Bottom you may put ſmall Iron Ferrills and two ſtrait Staves about 5 Foot each.

Before you meaſure with the Chain, 'tis neceſſary to examine its Length by the off-ſet Staff, ſtretching it on level Ground in ſuch ſort, as when you meaſure with it.

Being thus provided, let the Leader of the Chain take the nine Arrows in his Hand, and one of the 5 Foot Staves, and let the Follower, ſtanding at the Station, direct him to place his Staff at the Chain's End, in a right Line with the Stations, and there to put down one of his Arrows, and then go on.

Let the Follower, being come to the Arrow, take it up, and put his Staff in the place thereof, and direct the Leader to place his Staff as before; then let the Leader, ſtanding at his Staff, look back towards the laſt Station, and he will ſee the two Staves and the Station in one right Line, if they have directed right; but if not, the Leader muſt direct the Follower to place his Staff in the ſame right Line with the Station and the Leader's Staff, and ſo muſt each direct the other, till the two Staves and two Stations are in one right Line.

Let 'em thus proceed till they have meaſured to the Station, or till the Leader is nearer the Station than one Chain's Length; then will the Number of whole Chains meaſured, be expreſs'd by the Number of Arrows prick'd down, ſuppoſe 7; and the Leader holding the End of the Chain to the Station, the Follower will ſee how many Links are contain'd between the Station and laſt Arrow, ſuppoſe 60.

Now enter in the Field Book, the Chains and Links without any Diſtinction between them, and they will be 760 implying either 760 Links, or 7 Chains 60 Links; but the Links muſt always poſſeſs two Places after the Chains, as 7 Chains 4 Links muſt be written 704, and not 74; and 8 Chains muſt be written 800, alſo as ſoon as you have meaſur'd each Length, enter it down immediately in the Field Book, and never truſt to your Memory; alſo at the end of each Length, enquire of the Leader and Follower how many Arrows each have in their Hands, and if the Sum of the Arrows are not nine, the laſt meaſur'd Length is doubtful, and muſt be re-meaſur'd before you proceed.

When the Length is above nine Chains, let the Leader go on, and ſet his Staff down at the tenth, and let the Follower put his Staff in the place of the Leader's, and give the Leader the nine Arrows, and then proceed as before; but enter theſe 10 Chains immediately in the Field Book, and if the Length is 10 Chains more, enter 20; alſo obſerve it is uſual to allow 5 Links from the Stem of the quickſet Hedge, for the Breadth of the Ditch, except the Cuſtom or Agreement is otherwiſe; but the Cuſtom of the Place generally is the Surveyor's Rule.

SECT. III.

Shewing how to make a Plott of one Field, or ſeveral Fields, upon the Paper on the Plain Table, by placing the Inſtrument at one or more Stations about the Middle, from whence the Angles may be ſeen.

Let *Fig.* 3. be ſuppos'd to repreſent two Fields or Encloſures, a Plott of which is deſir'd, and firſt of the Field, *a l m o b.*

Having put your Plain Table in order, and obſerv'd the Needle to play well, put a Sheet of fair Paper thereon, and cruſh down the Frame, ſo that the Paper lyes ſmooth; then you may imagine the Paper on the Table to repreſent the Surface of the Land, and the Lines you ſhall draw thereon, to be the Bounders of the reſpective Fields or Encloſures in ſome Proportion or other, and if you make the Proportion thus, A Line drawn on the Paper an Inch long, is equal to, or in proportion to, the Length of one Chain on the Land, and if 5 Chains in Length, and 2 in Breadth, do contain the Quantity of one Acre on the Land, then 5 Inches in Length, and 2 in Breadth, ſhall alſo contain the Quantity of one Acre on the Paper, and takes up the ſame Quantity of Space thereon, as an Acre does in the Field; *vide Fig.* 1.

This being premis'd, we proceed to lay down the Lines that encloſe theſe two Fields of the ſame Length and Poſition on the Paper, which ſhall therefore include the ſame Quantity of Superficies as thoſe in the Field it ſelf in proportion, as 1 Inch to 1 Chain.

But if we make half, or a quarter of an Inch, or half a quarter (by which the following Di-

Dimenſions were laid down) on the Paper, to repreſent one Chain, it is the ſame in effect, only the Plott thereby is made leſſer; alſo the Inches, *&c.* on the Paper, are capable of being ſubdivided, as the Chain is into Links.

Firſt, place the Table ſomewhere about the middle of the Field, from whence, if poſſible, you can ſee all the Angles, as at ⊖, and make an Hole in the Ground, over which by the help of a Plummet and String, ſet the Center of the Table, by applying the String to the head of the Staff, and having ſet the Inſtrument ſteady on the Ground, turn the Table about till the Needle hangs over the Flower de Luce in the Box, (or if 'tis more convenient, turn the Length of the Table to the Length of the Plott, that it may, if poſſible, lye on one Sheet of Paper, and note, on a Bit of waſte Paper, the Diviſion in the Box the Needle hangs over when at reſt,) and then ſcrew the Table faſt. Aſſign on the Paper a Point, or ſtick a Pin at ⊖, (to repreſent the Hole in the Ground or preſent Station) to which Point, apply the fiducial Edge of the Index, and turn it about, keeping the Edge cloſe to the Point or Pin at ⊖, till through the Sights you ſee the Hair cut a Staff or Mark, ſet up exactly in one of the Angles, as at *a*, then by the Edge of the Index, draw a Line from the Point ⊖ towards the Angle *a*, with the Point of the Compaſſes, without regarding the Length, ſo it be long enough.

Let the Mark be left at *a*, and cauſe others to be ſet up round the Field, at every Angle therein, as at *l m o b*, to every one of which direct the Sights, and when the Hair therein cuts the Mark (keeping the Edge of the Index cloſe to the Point ⊖) draw the ſeveral Lines ⊖ *l*, ⊖ *m*, ⊖ *o*, ⊖ *b*.

Now ſee whether the Needle continues to hang over the ſame Point in the Box as when you firſt planted the Table, alſo lay the Edge of the Index to the Line ⊙ *a*, and if then the Hair in the Sights cuts the Mark at *a*, and the Needle hangs over the ſame Point as at firſt, you may conclude the Table hath not been mov'd out of its firſt Poſition, which is carefully to be obſerv'd.

In the next place we proceed to make the Lines ⊙ *a*, ⊙ *l*, *&c.* of their juſt Length, and to that end apply the Ring at one end of the Chain to the Hole under the Table, and let the Chain be ſtretch'd at length towards one of the Angles as at *a*, and when I have meaſured up thereto, (obſerving the Directions before laid down for meaſuring with the Chain,) I find the Length of the Line ⊙ *a*, to contain 3 Chains 60 Links, or 360 Links, which note in a Bit of Paper.

Having found the Length of the Line ⊙ *a* on the Ground, I proceed to make that on the Paper of the ſame Length, to correſpond therewith in Proportion, as an Inch to a Chain, or any other Proportion as ſhall be moſt convenient.

Therefore having provided a Scale and Compaſſes, becauſe the Length of the Line I am about to take off, is 360, or 3 Chains 60 Links: I ſet one Foot of the Compaſſes in the Line of Inches, *&c.* at 3, and extend the other to 60 in the diagonal Diviſions; thereby taking off 360 Links, then the Compaſſes remaining at this Extent, I ſet one Foot in the Point ⊙ on the Paper, and let the other fall in the Line ⊙ *a*, where I make a viſible Mark or Prick with the Compaſs Point, in order to find it again preſently.

Note, each whole Inch, ½ Inch, *&c.* on the Scale, repreſents one Chain, and the Links, or hundredth Parts of the Chain, are taken off from one whole Inch, ½ Inch, *&c.* divided alſo into 100 Parts, by diagonal Lines drawn croſs the Scale; for each 10*th* of that Diviſion repreſents 10 Links, and is divided into other ten Parts, by the croſſing of the diagonal Lines. Any Inſtrument-maker that ſells this Scale, will preſently ſhew the Uſes of theſe Lines, or the Sight thereof will be a ſufficient Information; only it may be obſerv'd, that theſe Scales are beſt made of Braſs, and the Joints of the Compaſſes are chiefly to be obſerv'd, which ſhould have an equal eaſy Motion without leaping, and that the Points be well temper'd, and cloſe in a Point exactly.

Obſerving the Directions before laid down, I firſt meaſure with the Chain the Length of the ſeveral Lines ⊖ *l*, ⊖ *m*, ⊖ *o*, and ⊖ *b*, and then transfer the Length of each Line on the Ground to its Repreſentative on the Paper, making viſible Marks where the end of each Line falls, as at *a*, *l*, *m*, *o*, *b*.

And here it may be obſerv'd, that I generally meaſure one Line from the Inſtrument to an Angle, and the next from the Angle to the Inſtrument, till all are finiſh'd, and note the Length of each Line as I meaſure it in a Piece of waſte Paper, and never truſt to my Memory; then obſerving which Line I began with, I ſet on its true Length on the Paper on the Table, and the reſt of the Lines in their order.

Laſtly, I join the Points *a*, *l*, *m*, *o*, *b*, with Ink Lines, becauſe they ſhould not rub off, (and for this purpoſe a drawing Pen is requiſite,) as the Lines *a l*, *l m*, *m o*, *o b* and *b a*, which conſtitute the Bounders of the Field *a l m o b*.

It may be a young Beginner will take ſome Pleaſure to meaſure croſs ſome part of the Plott on the Paper, as the Diſtance from *a* to *o*, or from *a* to *b*, with his Scale and Compaſſes, and afterwards meaſuring the ſame Diſtance on the Ground with the Chain, he will find them both exactly to agree, if the Plott be truly laid down.

Having finiſh'd this Field, I cauſe a Staff to be ſet up with a Paper thereon in the next, in a convenient Place, from whence I can view all the Angles; but if ſuch a Station can't be found, I chuſe the moſt convenient as at Θ 2.

The Table ſtanding at Θ 1, in the Field *a l m o b*, in the ſame Poſition as at firſt, (which it muſt do, or the Plott of the next Field can't be truly laid down in reſpect of the laſt) I lay the Index to the Point Θ, and turn it about thereon, till the Hair in the Sights cuts the Staff or Mark in the next Field at Θ 2, and holding the Index faſt in that Poſition, I draw a Line by the Edge thereof, from Θ 1, towards Θ 2, in the next Field, and take care to continue it long enough; then remove the Table, and place a Staff with a Mark thereon, in the Hole over which the Center of the Table was plac'd, and meaſure with the Chain the neareſt Diſtance between Θ 1, (in the Field *a l m o b*,) and Θ 2 in the next Field, (drawing the Chain through the Hedge in a ſtrait Line, and ſet on the Diſtance 621, (by the Help of the Scale and Compaſſes) from Θ 1 to Θ 2.

Now I take away the Staff, and plant the Center of the Table over the Hole, in which the Staff ſtood at Θ 2, and ſticking two Pins, or the Points of two ſmall Needles in Θ 1, and Θ 2, apply the Edge of the Index thereto, ſo as it lyes exactly on the Line Θ 1, Θ 2, and keeping it in this Poſition, turn the Table about till the Hair or Thread in the Sights cuts the Staff or Mark in the laſt Field, and then ſcrew the Table faſt that it ſtir not out of this Poſition, till I have finiſh'd the Obſervations in this Field, (but obſerve to turn that Part of the Table mark'd with Θ 1, towards its Repreſentative in the laſt Field.)

When the Needle hath ſettled, and is at reſt, obſerve whether it hangs over the Flower-de-luce or ſame Diviſion in the Box, as at ⊙ 1 in the laſt Field; which it will do if you have made your Obſervation truly, and the Needle be good; and if you were to move the Table to never ſo many Stations, the Needle will ſtill point to the ſame Diviſion in the Box, which obſerve; becauſe the removing the Table from one Station to another is the greateſt Difficulty in this Way of Surveying.

Having cauſ'd Marks to be ſet up in ſo many of the Angles in this Field, as you can conveniently ſee, from the preſent Station, as at *k*, *i*, *h*, *g*, lay the Index to the Point ⊖, and direct the Sights to *k*, *i*, *h*, *g*, drawing Lines by the Edge of the Index towards every one of them; then meaſuring the Length of the ſeveral Lines ⊖ *k*, ⊖ *i*, ⊖ *h*, ⊖ *g*, with the Chain, ſet on the ſeveral Lengths of theſe Lines on the reſpective Lines on the Paper (as before directed,) marking the Points *k*, *i*, *h*, *g*, where the Ends of the Lines fall from ⊖: Laſtly, join the Points *l k*, *ki*, *i h*, and *h g*, with ink Lines, and they conſtitute the Bounders of ſo much of the preſent Field, as you can conveniently ſee from this Station.

But there is no occaſion to meaſure to the Angles *l* or *m* with the Chain, except that it may be ſome Satisfaction, as aforeſaid, to ſee the Lines on the Paper, and thoſe on the Ground to agree.

Obſerving the former Directions for removing the Table, let it be plac'd in its true Poſition at ⊖ 3 in this Field; and direct the Sights to the Angles *f*, *e*, *d*, and *c*, and when the ſeveral Diſtances from ⊖ 3, to *f*, *e*, *d* and *c*, are ſet on the Paper, join the Points *g f*, *f e*, *e d*, *d c*, and *c b*, with ink Lines, ſo is the true Plott of theſe two Fields, *a l m o b*, and *l k i h g f e d c l o m*, laid down on the Paper in ſuch Proportion, as the Scale you made uſe of is to the Chain.

But obſerve that if the Hedge *b c*, had been ſo thick, that from ⊖ 3, you could not have ſeen the Angle *d*, or other Obſtruction had hinder'd your Sight or Meaſuring thereto, you muſt have remov'd the Table to another Station; but when you can (as commonly you may) by holding aſide the Boughs or otherwiſe, ſee the Mark, and by drawing the Chain through the Hedge, meaſure the Line from ⊖ 3, to the Angle *d*, 'tis a better way than to remove the Table, for the fewer Stations you make, the better, and the Work will be more truly laid down, which remember.

It would be only repeating the ſame thing over again, to give Directions how to ſurvey a Field from a Station taken in any Angle thereof, from whence the reſt may be ſeen; as if it had been more convenient in the Field *a l m o b*, to have planted the Table at the Angle *a*, the Sights muſt have been directed from thence to the reſt of the Angles *l*, *m*, *o*, *b*, and the Lines meaſured on the Ground, from *a* to *l*, *m*, *o* and *b*, whoſe Length laid down on the Paper from *a*, would give the ſame Points *l*, *m*, *o*, *b*, as if the Station had been in the Middle of the Field, and when the Bounders are drawn, they will be in the ſame Poſition as before.

If you would draw a Meridian, or a North and South Line through the Plott, turn the Table about, till the Needle hangs over the Flower-de-luce in the Card, and laying the Index on ſome of the equal Diviſions on the ſides of the Frame, draw a Line cloſe by the Edge, which ſhall be a meridian Line; and if you croſs this Line by another at Right Angles, that ſhall ſhew the Eaſt and Weſt Points.

SECT. IV.

Directions for caſting up the Content of any Piece of Land.

The next thing that lies before us is the Manner of Calculating the Quantum of the Superficies encloſed by the Lines on the Paper, as they repreſent the Bounders in the Field; that is to ſay, how many Acres, and Parts of an Acre are contain'd therein.

In order thereto, theſe ſeveral Things may be premiſed: Firſt, That every Magnitude is menſurable by ſome Magnitude of the ſame Kind; as, a Line by a Lineal Foot, &c. a Superficies by a Square Foot, &c. and a Solid by a Solid Foot, &c. The Superficial Meaſure may be conceived, by imagining *Fig.* 2. to be a Field, as now divided into 100 Squares, every Square being one Chain, having a Chain for its Side: Now if the Field be juſt one Chain broad, the Number of Square Chains will be equal to the Number of Lineal Chains in the Length of the Field: But if the Field be 2, 3, 4, &c. Chains broad, the Number of Square Chains will be twice, thrice, or four times ſo many ſquare Chains; ſo this Field being 10 Chains long, and 10 Chains broad, the Number of ſquare Chains in it are, 100, *viz.* 10 multiply'd by 10, gives 100; or if it had been 40 Chains long, and 5 broad, the Number of ſquare Chains would be 200.

2. That the Menſuration of all ſuperficial Figures, as Land, &c. depends on the exact Meaſuring of certain regular Figures, as the Parallelogram, Triangle, &c. ſo that if any Plot of Land be not one of theſe Figures, it muſt be reduc'd into

ſome or one of theſe Forms before it can be meaſured.

3. A Parallelogram is a quadrilateral Figure, each of whoſe oppoſite Sides are parallel, and the Diagonal divides the ſame into two equal Parts, as the Parallelogram *a b c d*, *Fig.* 5. the oppoſite Sides and oppoſite Angles of which are equal between themſelves, and the Diameter or Diagonal *a c* biſects the Parallelogram.

4. A Right-lin'd Triangle, is a Figure comprehended within three ſtrait Lines.

We need not here take notice whether a Triangle be Right or Oblique-angled, or by what Name diſtinguiſh'd, whether an Iſoſceles, Scalenum, *&c.* becauſe they are all meaſured by one and the ſame Rule.

5. A Trapezia is an irregular four-ſided Figure, comprehended under 4 unequal Sides and Angles.

To this we ſhall add theſe two uſeful Theorems following.

Theorem 1.

That Parallelograms conſtituted upon the ſame Baſe, and between the ſame Parallels, are equal, *Euclid. lib.* 1. *Prop.* 35.

Let *a b c d*, *e b c f*, be Parallelograms conſtituted upon the ſame Baſe *b c*, and between the ſame Parallels *a f*, and *b c*, then the Parallelogram *a b c d*, is equal to the Parallelogram *e b c f*.

For becauſe *a b c d* is a Parallelogram, *a d* is equal to *b c*, and for the ſame Reaſon *e f* is equal to *b c*, wherefore *a d* ſhall be equal to *e f*, but *d e* is common, therefore *a e* is equal to *d f*, but *a b* is equal to *d c*, wherefore *e a*, *a b*, the two Sides of the Triangle *a b e* are equal to the two Sides *f d*, *d c*, each to each, and the Angle *f d c*, equal to the Angle *e a b*, the outward one to the inward one, therefore the Baſe *e b* is equal to the Baſe *f c*, and the Triangle *e a b*, to the Triangle *f d c*.

If the common Triangle *d g e* be taken from both, there will remain the Trapezia *a b g d*, equal to the Trapezia *f c g e*, and if the Triangle *g b c*, which is common, be added, the Parallelogram *a b c d*, will be equal to the Parallelogram *e b c f*, which was to be demonſtrated. *Vide Fig.* 4.

Theorem 2.

If a Parallelogram and a Triangle have the ſame Baſe, and are between the ſame Parallels, the Parallelogram will be double to the Triangle, *Euclid. Lib.* 1. *Prop.* 41.

Let the Parallelogram *a b c d*, *Fig.* 5. and the Triangle *e b c*, have the ſame Baſe, and between the ſame Parallels *b c*, *a e*, then the Parallelogram *a b c d*, is double the Triangle *e b c*.

For join *a c*, then the Triangle *a b c* is equal to the Triangle *e b c*, for they are both conſtituted upon the ſame Baſe *b c*, and between the ſame Parallels *b c*, *a e*, but the Parallelogram *a b c d*, is double the Triangle *a b c*, ſince the Diameter *a c* biſects it, wherefore likewiſe it ſhall be double to the Triangle *e b c*, which was to be demonſtrated. *Vide Fig.* 5.

By the laſt *Theorem*, a Parallelogram having the ſame Baſe with a Triangle, and lying between the ſame Parallels, is double to the Triangle; therefore if the Baſe of a Triangle be of the ſame Length with one ſide of a Parallelogram, and the Perpendicular of the ſame Height, as the other ſide of the Parallelogram, thoſe Triangles are equal but to half that Parallelogram. *Vide Fig.* 6.

If a Weight (as a Bullet) was ſuſpended at *e*, *Fig.* 6. and from thence let fall on the oppoſite Line *b d*, it wou'd deſcribe the Perpendicular Line *e f*, then a Perpendicular is the neareſt Diſtance, or ſhorteſt Line that can poſſibly be drawn from any Angle to its oppoſite Side.

And here it may be convenient to inſert the Manner of raiſing or letting fall a Line perpendicular to another.

Let a Perpendicular be raiſed on the Line *d e*, from the Point *c*, *Fig.* 7. Open the Compaſſes to a convenient Diſtance, and mark out the two Points *a* and *b*, then opening them ſomething wider, you may by ſetting one Foot in *a* and *b*, ſeverally deſcribe the two Arches cutting one another at the Point *f*, from which draw the Perpendicular *f c*, to *c*, alſo the Line *f c*, continued, will croſs the Line *d e*, at Right Angles.

Let a Perpendicular be raiſed from the End of the Line *a b*, at *b*, *Fig.* 8. Open the Compaſſes to an ordinary Extent, and ſetting one Foot in the Point *b*, let the other fall at Adventure, as at ⊖, then without altering the Extent of the Compaſſes, ſet one Foot in the Point ⊖, and with the other, croſs the Line *a b*, at *d*, and deſcribe the obſcure Arch *d d*, then lay the Ruler to *d* and ⊖, and draw the obſcure Line *d* ⊖ *e*, through the Arch. Laſtly, apply the Ruler to the Point of Interſection at *f*, and to the Point at the End of the Line *a b*, and draw the Perpendicular *c b*.

Let a Perpendicular be let fall from the Point *c*, upon the Line *a b*: Set one Foot of the Compaſſes in the given Point *c*, and with the other, deſcribe ſuch an Arch of a Circle, as will croſs the given Line *a b*, in two Points, *viz.* *d*, *f*, then biſect the Diſtance between the two Points *d* and *f*, as at *e*, and draw the Perpendicular *c e*.

This is no more but the Firſt Problem reverſed: Alſo a Perpendicular may be let fall nigh the End of a Line by the Second.

Note, Thoſe Problems touching Perpendiculars, aim at no greater Matter, than may be performed in a mechanical Way, by the help of a ſmall Square, exactly made as a Square Protractor, or for want thereof, a Scale in a Caſe of Inſtruments, that hath a Right Angle, and true Sides, or the Square therein, in the Form of a Carpenter's, *&c.* for if you apply one Leg of ſuch a Square to any Line, ſo as the Angle of the Square may touch the End of the ſaid Line, or any other Point where the Perpendicular is to be raiſed, you may by the other Leg, draw the Perpendicular. In like manner may you let fall a Perpendicular from a Point aſſigned, by applying one Leg of the Square to the Line, ſo as the other may touch at the ſame Line the aſſigned Point, whence you may draw the Perpendicular by that Leg that touches the Point.

If the Angle of the Square, be a little Blunt by Wearing, you muſt allow for it when you apply it to the Point in a Line, and when you are drawing a Perpendicular, you muſt ſtop before you reach the given Line, and then by applying the Leg of your Square, to that Part of the Perpendicular already drawn, ſo as that Part of the Leg may paſs clearly over the Line, you may draw the Perpendicular as exactly, as if the Angle had been true. The like Courſe is to be taken, when a Line is to be croſſed by another drawn quite through it at Right Angles.

6. Every Figure encloſed with 3 Right-lines is a Triangle, and in the Menſuration thereof, only the Length of the Baſe, and Height of the Perpen-

dicular is conſiderable, and any of the Lines may be made the Baſe, though commonly the longeſt is, and a Line let fall from the oppoſite Angle upon, or made to touch the Baſe in the neareſt Point, is the Perpendicular, and you are not confin'd to any Angle, but may let fall the Perpendicular from what Angle you pleaſe, taking the Line on which it falls for the Baſe.

7. The Area or Content of the two Primitive Right-Lin'd Figures, the Square or Parallelogram and Triangle is found by multiplying the Length of the Square or Parallelogram by its Breadth, and the Baſe of the Triangle by half the Perpendicular, or the whole Perpendicular by half the Baſe, or the whole Baſe by the whole Perpendicular, then the half of that laſt Product, is the Content of the Triangle.

And here it may be worth obſerving, that the Multiplier in any of the Multiplications made uſe of in caſting up any Menſuration, is an abſtract Nnmber, as well as in all other Multiplications whatſoever, which may prevent the falſe Conſequences uſually drawn from multiplying Feet, *&c.* by Feet, (*viz.*) that of multiplying by a contract Number (as half a Crown by half a Crown) which is contrary to the Nature of Multiplication, whoſe Operations are only compendious Additions, either of the Multiplicands, or ſome Part of it continually to its ſelf or its Part.

8. The Parallelogram or Square, being the original Figure from which are deduced all Computations, that relate to the caſting up the Content of a Superficies, a Line drawn from any Angle therein to its oppoſite Angle, may be divided into two Triangles (which dividing Line is called the Diagonal, as aforeſaid) both of which Triangles taken together, are equal to

the Square or Parallelogram, and one of them equal to half of it, and any manner of Figure that hath four Sides, whether equal or parallel, or neither, let it be called a Trapezia-Rhombus, *&c.* is capable of being divided and caſt up in the ſame manner.

9. Then any irregular Figure, let it conſiſt of never ſo many Sides, may be divided by ſuch Diagonals into a Number of Triangles, *&c.* which ſeparately caſt up and added together, their Sum is the Content of the whole Figure.

10. And almoſt all Fields to be met with in Surveying, being bounded with a Number of unequal Lines, we firſt take the Plott thereof by ſome Inſtrument, and lay it down on Paper, and by drawing Diagonal Lines through it, reduce it into Triangles, *&c. Vide Fig.* 10.

11. And theſe Triangles or Squares, being meaſured by the Chain of 100 Links, when caſt up, their Content is given in the loweſt Denomination, (*viz.*) ſquare Links, as in Figure 10: 10 Chains multiplied by 10 Chains, gives 100 ſquare Chains; or, which is all one, 1000 Links by 1000 Links, gives 1.000000 ſquare Links in the loweſt Denomination, only making the Links to poſſeſs two Places of Figures after the Chains, as 6 Chains 54 Links muſt be written 654, without any Point of Separation between them, and 10 Chains muſt be written 10.00.

12. In one ſquare Chain, there are 10000 ſquare Links, and 100000 ſquare Links in an Acre; the Chain therefore is divided into 100 Parts or Lengths (ſuch as a Link is made to be) on purpoſe, that all Operations may be made in a decuple Manner, and to ſave the trouble of Diviſion: For as the Acre is limitted by Statute, this Number 100000 is the Diviſor in the loweſt Denomination (*viz.*) Links. So if a Field contains

1654321 ſquare Links, we need not to find the Number of Acres therein divide it by 100000, the ſquare Links in one Acre; but according to the old Rule, when a Diviſor conſiſted of 1 and Cyphers, cut off from the Right-hand, ſo many Places of Figures of the Dividend, as the Diviſor hath Cyphers, accounting them the Remainder; ſo ſhall the reſt on the left Side be the Quotient; ſo the five laſt Figures cut off from the Right, there are 16 Acres for the Quotient, the remainder Parts of an Acre. Then by the known Rules in Decimal Arithmetick (*viz.*) multiplying Decimal Fractions by known Parts in the next inferior Denomination, gives thoſe known Parts in Integers; due regard being had to the Separation. So 54321, multiplied by 4, the Roods in an Acre, produces 217284, from which Product cutting off 5 Places of Figures towards the Right, leaves 2 Roods on the left; and that Remainder ſo cut off, being multiplied by 40, produces 691360; and from this laſt Product, ſeparating 5 Places by a Point, gives 6 Poles on the Left, and the Remainder $\frac{91360}{100000}$ Parts of a Pole.

From what hath been ſaid, the general Rule for caſting up the Content of a Piece of Land may be given.

General Rule.

Set down the Number of Chains and Links in the Order of Multiplication, making the Links poſſeſs two Places after the Chains; and from the Product cut off by a ſeparating Point 5 Figures to the Right-hand, ſo ſhall thoſe on the Left be Acres: Then multiply the five Figures ſo cut off by 4, (the Roods in an Acre) ſeparating five Places alſo from that Product towards the

Right Hand; then the Figures on the left of the ſeparating Point are Roods.

Laſtly, Multiply this laſt Remainder by 40, (the Poles in a Rood) and ſeparate five Places to the Right from that Product, and the Figures on the Left ſhew the Number of Poles.

So in *Fig.* 10. the Field *a l m o b* being divided into the Triangle *l m o*, whoſe Baſe is 660, and the Perpendicular let fall from the Angle *m*, on the Baſe Line *l o*, is 252.

Therefore half 660, multiplied by whole 252; or whole 660 by half 252; or whole 660, by whole 252, then the half of this laſt Product is the true Content. Uſe any of theſe Methods, the Content of the Triangle *l m o* will be 83160.

The Diagonal Line *l b* divides the Trapezia *l o b a* into two Triangles, *l o b* and *l b a*, which might be ſeparately caſt up as the Triangle *l m o*; but the quicker Way is, to add the two Perpendiculars *o z* and *a x* together, and by that Sum multiply the Line *l b*, which is a common Baſe to both Triangles, and halve the half-Product for the true Content of the Trapezia. See the following Work.

Baſe 660——*l o*
Perp. 252——*m y*
1320
3300
1320
166320

Perp. 290——*a x*
Perp. 272——*o z*
562 Sum
Baſe 800——*l b*
449600

166320 } Product
449600 }
615920 double Content.
Acres —— 3.07960 true Content.
4
Roods —— .31840
40
Poles —— 12.73600

Acres	Roods	Poles	Parts of a Pole.
3 :	0 :	12 :	$\frac{73600}{100000}$

The Baſe *l o* multiplied by the Perpendicular *m y*, produces 166320, which is double the Content of the Triangle *l m o* in ſquare Links. Alſo the Perpendicular *a x*, added to the Perpendicular *o z*, makes the Sum of both 562, which multiplied by 800, the common Baſe to both Perpendiculars, produces 449600, which is double the Content of the Trapezia *l o b a* in ſquare Links.

Therefore (for avoiding Fractions) the double Content of the Triangle *l m o* 166320, added to the double Content of the Trapezia *l o b a*, 449600 gives 615920 the double Content of the Field *a l m o b* in ſquare Links, the half of which (*viz.*) 307960 is the true Content of the Field *a l m o b* in ſquare Links, which reduced into Acres, *&c.* as before directed, gives 3 Acres, 12 Poles, and a little above half a Pole, for the true Content of the Field *a l m o b*; but the Parts of a Pole are ſeldom regarded.

In the ſame manner the Field *b c d e f g h i k l m o*, *Fig.* 10. being divided into Trapezias and Triangles, add both the Perpendiculars of each Trapezia together, and by that Sum multiply the Diagonal or Baſe: Alſo multiply the Baſe of each Triangle by the Perpendicular, and ſet the Product of each Trapezia and Triangle in an orderly manner, one under another, and add them all together into one Sum, the half of which Sum is the Content of the Field in ſquare Links, which reduce into Acres, *&c.* as aforeſaid.

But remember to meaſure the Baſes and Perpendiculars by the ſame Scale that the Plott was laid down by, and contrive to reduce the Field into as large Trapezias and Triangles as poſſible, for the fewer you make, the exacter will the Work be caſt up; and draw the Baſe-lines neat and ſmall, and exactly from Angle to Angle, and let the Perpendiculars juſt touch the Line, but not paſs over it, at the neareſt Diſtance from the Angle that may be; and for this End a good Pair of Compaſſes, and a Diagonal Scale are moſt proper; and the larger Scale you uſe the better, if the Compaſs of the Plott will admit thereof.

SECT. V.

Shewing how to make the Plott of any Field or Encloſure, on the Paper on the Plain Table, by going round the ſame, and taking Off-ſets to the Bounders, &c.

Let *Fig.* 11. repreſent a Field to be plotted by the Plain Table.

Now the former Method of planting the Table at one Station or more, in the middle of the Field, and meaſuring from thence the Diſtance to every Angle, is eaſieſt for a Beginner, but is not convenient in many Caſes; becauſe he may be hindred by Firze, Water, *&c.* from meaſuring the Lines to all the Angles; and in many Fields where the Fences are as irregular as the Side *a e* in this Field, he will be obliged to meaſure a great Number of ſuch Lines.

'Tis therefore beſt to plant the Inſtrument at the moſt remarkable Angles, and meaſure round the Field, for by this Method, all Sorts of Land may be meaſured (ſo the Plan be not too large for one Sheet of Paper,) either within or without the Plott, as Convenience ſhall determine.

Note, This Mark ⊙, always repreſents a Station, ... a Prick Line repreſents the Station Line, and —— a Black Line the Bounder.

Firſt ſet up a Mark at *a*, and draw a Line on the Table, to repreſent *a b*, in the Field, then meaſure the Diſtance to the Hedge from ⊙ 20 Links, which ſet from ⊙ to *f*, alſo meaſure the Diſtance from ⊙ *a*, to ⊙ *b*, 840 Links, which ſet on the Line *a b*.

But inſtead of uſing a Scale and Compaſſes, you may ſet on the Diſtance by the Plotting Scale only, ſuch as aforementioned, whoſe Edge is champered, and the Numbers, and Diviſions ſet cloſe thereto; (being much readier than Compaſſes, and generally uſed by the beſt Surveyors) each Diviſion repreſenting a Chain, being numbred 1, 2, 3, *&c.* and each of thoſe Diviſions being again ſub-divided into ten Parts, one of which ten Parts repreſents ten Links.

Therefore lay the Edge of this Plotting Scale cloſe to the Line *a b*, the Beginning of the Numbers coinciding with *a*, and encreaſing towards *b*, and becauſe the Length of the Line *a b*, is 840, make a Mark with a Needle or protracting Pin againſt 840, cloſe to the Edge of the Scale.

But if the Number had been 845, *&c.* you muſt gueſs at the odd Links, which you may do by a Scale of $\frac{1}{4}$ of an Inch within 2 in an Hundred, and not miſtake, but with a larger Scale much nearer.

Having drawn the Line *a b*, place the Table at *b*, and lay the Edge of the Index cloſe to the Line *a b*, and turn the Table about till you ſee the Mark at *a*, and there ſcrew it faſt; then turn the Line the Index about on *b*, till you ſee a mark at *c*, and draw *b c*, with the Point of the Compaſſes, or a Black-lead Pencil; alſo direct the Sights to the Barn, and draw the Obſcure Line *b z*, not regarding its Length, ſo it be long enough.

When the Needle hath ſettled, take notice what Diviſion in the Box it points to, for to that Diviſion it will point at every Station through the Plott, if your Work be true, and the Needle good, as aforeſaid; but becauſe 'tis not convenient to truſt to the Needle when we can do without it, I ſhall here lay down a ſurer way to correct an Error, before 'tis communicated to the following Part of the Work.

In the next place, Meaſure the Diſtance from ⊖ *b*, to the Hedge 17 Links, which ſet from ⊖ to *g*, and draw the Bounder *f g*, alſo meaſure the Diſtance from ⊖ to *h*, which ſet on the Paper from ⊖ to *h*, and continue the Bounder *f g*, in a Strait Line, as you ſee it in the Field.

Remove the Table from *b*, and ſet up a Staff with Paper thereon in the Hole, over which the Center of the Table ſtood, as by former Directions, and meaſure from *b*, towards *c*, with the Chain, but when you come over againſt the Bend in the Hedge at *i*, meaſure the Diſtance from the Chain Line *b c*, to that Bend 7 Links, which ſet from the Chain Line *b c*, to *i*, and draw the Bounder *i h*, through *h*, till it cuts the Bounder *f g*, conſtituting that Corner of the Field.

Meaſure on to *c*, 620 Links, which ſet from *b* to *c*; now the Reaſon why we made the Station *b*, ſo far from the Corner, is to avoid Planting the Inſtrument too often, for if we had continued the Station Line *a b*, into the Corner, we muſt have made another Station at *i*, otherwiſe we could not ſee to the Angle at *c*, for the fewer Stations we make, the exacter will be the Work, as aforeſaid.

Now in order to examine the Length of *b c*, and alſo its Poſition in reſpect of *a b*, do thus: Plant the Inſtrument at *c*, and lay the Index on the Line *b c*, and by turning the Inſtrument about, direct the Sights to *b*, and there ſcrew it faſt; then turn about the Index on the Point *c*, towards the Mark at the Angle *a*, in the Field, and if the Edge does not cut the Point *a*, in the Table, the Line *b c*, is falſe, either in Poſition or Length, and therefore muſt be corrected before you proceed.

The Line *b c*, being truly laid down, and the Table ſtanding at *c*, in the ſame Poſition, lay the Index to the Point *c*, and turn it about thereon, till the Hair in the Sights cuts the Mark at *d*, and draw the Line *c d*, alſo direct the Sights to the Middle of the Barn, the Index being turned about on the ſame Point *c*, and draw the Obſcure Line *c x*, croſſing the other Obſcure Line *b z*, ſo ſhall the Point of Interſection determine the Situation of the Barn in the Middle of the Field, which you may prove by meaſuring on the Ground thereto, from any Part of the Field.

Next meaſure the Diſtance from the ⊖ at *c*, to the Hedge 6 Links, which ſet from ⊖ to *k*, and draw the Bounder *i k*, continuing the Line through *k*, alſo meaſure the Diſtance to the other Hedge *c d*, from ⊖ *c*, 15 Links, which ſet off to *l*.

Remove the Table from *c*, and place a Mark there, and meaſure the Diſtance from *c* to *d*, 481 Links, which Diſtance ſet on the Line *c d*, then plant the Table at *d*, and lay the Index on *c d*, and turn the Table about till you ſee a Mark at *c*, and then ſcrew the Inſtrument faſt.

Next, Examine the Length and Poſition of *c d*, in reſpect of *b c*, as before directed, then turning the Index about on *d*, direct the Sights to *e*, and draw the Line *d e*, and ſet off the Diſtance from ⊖ *d*, to the Hedge at *m* 10 Links, and from *m*, draw the Bounding Line *m l*, continuing it ſtreight through *l*, till it croſſes *i h*, as you ſee it to do it in the Field.

Leave a Mark at *d*, and plant the Table at *e*, having firſt meaſured the Length of *d e*, 364 Links, and ſet it on its proper Line from *d* to *e*, on which Line *d e*, lay the Index, and turning the Table about till you ſee the Mark at *d*, there ſcrew it faſt, and having proved the Line *d e*, to be truly laid down in reſpect of *c d*, turn the Index about on *e*, till you ſee the Mark at *a*, and draw the Line *e a*, which will cut through the Point at *a*, alſo direct the Sights to the Angle *p*, and draw ⊖ *p*, and to *q*, drawing ⊖ *q*, on the Paper.

Then meaſure with the Chain the Diſtances ⊖ *p*, and ⊖ *q*, ſetting thoſe Diſtances on their proper Lines, and draw the Bounders *p o*, and *q p*.

Now meaſure on the Line *e a*, and when you come againſt the Bend in the Hedge at *r*, meaſure the Diſtance from the Chain Line *e a*, to that Bend 8 Links, which ſet on the Paper to *r*, and draw the Bounder *q r*.

In the ſame manner meaſuring on the Line *e a*, ſet off the Diſtances from the Chain Line to the Angles in the Bounder *s* and *t*, and draw the Bounders *r ſ*, *ſt* and *t f*, which croſſes the Line *g f*, near *f*, and when you have meaſured the Line *e a*, on the Ground, you will find it of the ſame Length as that before drawn on the Paper.

If the Diſtance from the Station to the Bends in the Hedge be great, 'tis the ſafeſt way to plant the Center of the Table over the Station Line, as at *w*, and laying the Index on the Line *e a*, direct the Sights to *e*, or *a*, by turning the Table about, and in that Poſition ſcrew it faſt; then direct the Sights to the Bends in the Hedge as, to *ſ*, or *t*, drawing Lines towards them, and ſetting off the Diſtances in the ſame manner as is done from ⊖ *e*.

In order to examine the Lengths and Poſitions of each Line before you proceed on the next, if you don't think it convenient to leave Marks at all the Stations round the Field; if you turn about the Index on the Point, repreſenting the preſent Station, till you ſee any one of the Marks before laid down, and if the Edge of the Index cuts that Point on the Paper, your Work is right; ſo you might have left a Mark at the Firſt Station *a*, and by that prove the Lengths and Poſitions of all the other Lines, as well as by the laſt but one you paſſed by.

But if you could not ſee the Mark at *a*, at all the other Stations, you may make uſe of any other Mark, as ſome Part of the Barn; or you may ſet up a Mark in ſome convenient Place, from whence you can ſee all the Angles.

But if the Mark you laſt us'd, is at too great a Diſtance from you, or lyes almoſt in a Strait Line with that you laſt laid down, then uſe ſome other Mark in its Stead, whoſe Poſition you have before found at one of the foregoing Stations.

Or inſtead of a Mark thus ſet up, you may uſe any remarkable Tree, Steeple, *&c.* that is not at too great a Diſtance from you, whether it be in the Land you are then Surveying or not.

How to Meaſure an inacceſſible Diſtance.

Laſtly, In the ſame manner as you found the Poſition of the Barn in the middle of the Field, *Fig.* 11. you may meaſure any other inacceſſible Diſtance; ſo if the Barn was ſo ſituated that you could not come nearer thereto, by reaſon of Water, or other Impediments, than the Line *b c*, yet you would know its Diſtance from *b*, or *c*.

The Inſtrument planted at *b*, and the Sights directed to a Mark at *c*, and alſo to the Barn, and the Lines *b z*, and *b c*, drawn on the Paper as before directed, and the Inſtrument removed from *b*, and planted at *c*, and the Sights directed to a Mark left at *b*, and alſo to the Barn, and the Line *c x*, alſo drawn on the Paper, cutting the other Line *b z*, then ſhall the Point of Interſection determine the Diſtance of the Barn from *b* or *c*, which you may find by meaſuring from *q* or *c*, or any other Part of the Line *b c*, by the ſame Scale with which you laid down the Line *b c*.

But 'tis convenient to make the Stations *b* and *c*, at ſuch a Diſtance from one another, that the Angle at the Point of Interſection may not be too Acute, leſt you be not able to diſtinguiſh nicely the Point of Interſection.

If *Fig.* 11. was a Wood, ſo that you could not meaſure the Station Lines within, you may as well make them on the Outſide, for the Plott will be the ſame, only the ſmall Pieces of Ground between the Station Lines, and Bounders, are excluded by the Bounders from being any Part of the Plott. Particular Directions in this Caſe are needleſs; *ſee the Figure.*

When you are about to meaſure a Plott of Land, and in doubt whether it will lye on one Sheet of Paper, you may place a Line or two croſſe the Plott, as you walk about to chooſe the moſt convenient Stations (reckoning ſo many Steps to a Chain, as you find by Experience carries you a Chain's Length) and thereby gueſs what Scale to make uſe of.

Alſo 'tis convenient to make a particular Remark at the Firſt Station in each Field, that you may readily find it when you come round to it again, in order to cloſe the Plott.

Alſo as ſoon as you have drawn the Plott of a Field, 'tis neceſſary to write the Name ſomewhere in the middle thereof.

There is another Way of Plotting a Field by the Plain Table (though ſcarce fit for Practice) by meaſuring one Line only, which in ſhort is this:

Plant the Table at *a*, *Fig.* 12. and direct the

Sights to the ſeveral Angles round the Field, keeping the Index cloſe to the Point *a*, and by the Edge thereof draw a Line towards every Angle, then place a Staff at *a*, and plant the Table at the other Station *b*, meaſuring the Diſtance between the two Stations, which Diſtance ſet on the Line *a b*, lay the Index on the Line *b a*, and turn the Table about till you ſee the Mark at *a*, and fix there the Inſtrument.

Then lay the Index to the Point *b*, and turn it about thereon, directing the Sights to the ſeveral Angles round the Field as before at *a*, and towards every one of them draw a Line, which will interſect the Lines before drawn at *a*, ſo ſhall the Points of Interſection determine the Place of all the Angles round the Field, and Lines drawn from Point to Point ſhall give the Bounders of that Field.

But if you be not very exact and curious in drawing the Lines, and alſo, if the Stations are not contrived in ſuch manner as may prevent the Lines Interſecting one another at very acute Angles you may commit groſs Miſtakes.

And here it may be obſerved in this as well as any other Caſe of the like Nature, that all Things that are to be determined by the Interſection of Right Lines are beſt determined when thoſe Lines Interſect each other neareſt Right Angles.

Therefore when Triangles laid down by the Length of their Sides interſecting one another with acute Angles, the Point determining where thoſe Lines interſect, is not ſo well determined as it ought to be.

CHAP. II.

Shewing how to Survey any Piece of Land, by the Theodolite or Circumferentor, and to protract the ſame.

SECT. I.

THE Plain Table is very uſeful for taking the Ground Plott of Buildings, and meaſuring Gardens, or ſmall Encloſures (where the ſhortneſs of Lines, and Multiplicity of Angles would be apt to breed Confuſion in protracting,) but by no means fit for ſurveying large Tracts of Land, becauſe the leaſt Moiſture, or Dampneſs in the Air, makes the Paper not only ſink, but run up when dry'd again, and thereby the Lines drawn thereon are diſorder'd, making the Content leſs than it ſhould be; and in the leaſt Rain or Miſt, the Inſtrument becomes altogether uſeleſs; alſo, when the Plott proves larger than will lye on one Sheet of Paper, there muſt more be pieced thereto with Glue or Paſte, which wetting only ſome Parts of the Paper, is liable to the aforeſaid Inconveniencies, neither can ſeveral Sheets of

Paper be joyn'd together after the Plott is drawn thereon, ſo as to meet exactly, and lye ſo flat as it ought to do; and if to theſe Inconveniences be added the tedioufneſs of compleating the whole Plott in the Field, when a Surveyor has his Aſſiſtants about him, that alone might be Objection enough to induce any Perſon to make uſe of fitter Inſtruments.

Here follows the Deſcription and Uſes of a New Theodolite, being the moſt abſolute Inſtrument yet invented for Surveying Land.

If we be not very exact and curious in meaſuring the Angles in the Field, the Plott on the Paper can never be truly laid down; and if the Inſtrument with which we meaſure theſe Angles be not well fram'd and divided, all the care we can take in making the Obſervations in the Field will be to little purpoſe; therefore, I thought it might not be improper firſt of all, to give a general Deſcription of a new Theodolite, which hath met with a general Applauſe from all Mathematicians that have ſeen it, and far exceeds any other Inſtrument that hath yet been invented.

For the Ball and Socket is ſo contriv'd, that the whole Inſtrument may be ſet as truly Horizontal, as by the help of any Rack, and with leſs than a tenth Part of the Trouble and Time, and this in meaſuring every Angle is abſolutely neceſſary; for Inſtance, ſuppoſe we were to meaſure an Angle on the ſide of an Hill, by one of the Theodolites as commonly made, and had ſet the Inſtrument as near a level as we could by the Eye, and then proceeded to make an Obſervation;

ſervation; if then the Limb be out of the Horizon, ſuppoſe but two Degrees; (and it can ſcarce be ſet nearer if ſo near, for the Ground being on a Declivity will deceive us) the Angle thus meaſured will be conſiderably falſe; for the Inſtrument thus planted on the ſide of the Hill, let the Telleſcope be directed to the firſt Object, and that part of the Limb next your Eye fixed two Degrees out of the Horizon, and then let the Telleſcope or Sights be turn'd round to the other Object, and elevated thereto, ſuppoſe ten Degrees; then the Index will cut on the Limb, the Number expreſſing the Angle, ſuppoſe ninety Degrees; now this Angle of ninety Degrees is meaſured above twenty one Minutes falſe, and if the Lines that form the Angle, happen to be long, this Error will be very conſiderable in regard of the true Content of that Piece of Land, and the Plott can never be expected to cloſe, if the Angles be thus meaſured; but in the uſe of this Theodolite, this Inconvenience is remedied, the Inſtrument being ſo eaſily ſet exactly Horizontal.

There is a Quadrant nearly, the Radius of the Inſtrument ſo fix'd over the Center, as to move exactly in a vertical Circle, within which is a Spirit level, and over that the Teleſcope fix'd thereto, ſo contriv'd that when the Bubble reſts in the middle of the Spirit-tube, the Horizontal Hair in the Teleſcope will cut an exact Level, and by its Motion in a vertical Circle, whatever Object this Hair cuts above or below, the true Level, its Elevation or Depreſſion will appear by the ſaid Quadrant divided and grav'd for that Purpoſe; there is alſo in the Teleſcope a vertical Hair to be us'd in the meaſuring Horizontal Angles, ſo that both the Horizontal and vertical Angles are obſerv'd at the ſame time, which is extream Uſeful in laying down the Plotts when the Hynothenuſal are to be reduc'd to horizontal Lines.

This Inſtrument is well contriv'd for working with the Needle only; for as ſoon as the Inſtrument is ſet ſteady on the Ground; the Needle will lye in the direction of the magnetick Meridian, and there be at reſt; and then the Point in the Box mark'd with 360, may be brought to the north End of the Needle, and there fix'd without ſtirring the Needle; alſo the Index and Teleſcope may be mov'd round to any Object in the ſame Manner; for the Head of the Staff is made of Braſs, and not liable to ſhake as the wooden ones are, which contributes much to the true meaſuring of an Angle, and the Index is mov'd round a conical Center, touching the Limb in three Places at 120 Degrees Diſtance, and if by much wearing it ſhould ſhake, that is inſtantly help'd by a Screw for that Purpoſe; for if the Index grows looſe and ſhakes, it will not cut the Minutes on the Limb to any Exactneſs.

The Pin, on which the Needle hangs, is made of temper'd Steel turn'd and poliſh'd in the Lath, and may be taken out and put in at Pleaſure, and is not ſcrew'd to the Box, but remains fix'd always in the ſame Poſition, whilſt the Box, Index, and Teleſcope are mov'd round it, and the Teleſcope fix'd to an Object without ſtirring the Needle, ſo that an Obſervation may be made both by the Limb and Needle at the ſame Inſtant.

And when the Teleſcope is directed to an Object, the whole Inſtrument is fix'd there in ſo firm a Manner, with ſmall Power, that the Motion of the Index when the Teleſcope is directed to the next, ſhall not move the Limb from the Poſition in which it was firſt fix'd; which in other Theodolites is very difficult to be done.

The whole Inſtrument is made very portable, and the Uſes thereof plain and ſimple ; one Teleſcope being apply'd to all the Operations, neither is any thing to be added or taken from it when we make uſe thereof.

Being thus provided with a good Theodolite ; we now proceed to ſhew the Manner of uſing it in meaſuring Land.

The moſt material Things to be done in the Field are two ; Firſt, to meaſure the Length of the Lines ; and Secondly, the Quantity of the Angles.

The manner of meaſuring Lines in the Field is already laid down ; we now proceed to the Angles.

SECT. II.

The Deſcription of an Angle.

An Angle is the metting of the two Lines in a Point ; provided the two Lines ſo meeting don't make one ſtrait Line, as the Lines *a*, *o*, and *x*, *o*, *Fig.* 12. meeting together in the Point o, form the Angle *a*, *o*, *x*.

Angles are meaſured by the Arch of a Circle deſcrib'd from the angular Point as a Center ; ſo the Angle *a*, *o*, *x*, is meaſur'd by the Arch of the Circle, *Fig.* 13. deſcrib'd from the angular Point *o* : The Arch of this Circle that meaſures the Angle *a*, *o*, *x*, being intercepted between the Lines *a*, *o*, and *x o*.

An Angle is ſaid to be equal to, greater or leſs than another, according as the Arch which meaſures it contains as many more, or fewer of the equal Parts into which the Circle is ſuppos'd to be divided.

The Circle is divided into 360 Parts or Degrees, and each Degree into 60 other Parts call'd Minutes; or ſuppos'd to be ſo divided, ſo that any Portion of the Circumference is expreſs'd by the Number of Degrees and Minutes it contains.

'Tis no matter whether the Circle be great or ſmall, for each is ſuppos'd to contain 360 Degrees (except that the Minutes are better eſtimated on a great Circle than a ſmall.)

The Line *o h*, is the Radius of the Circle, *Fig.* 13. *z*, *d*, is the Diameter, and paſſes through the Center *o*, dividing the Circle into two equal Parts; the Line *z e*, is the Chord of 60 Degrees joining the Extremities of the Arch *z e*.

Z o h, is a Right angled Triangle, *z o* the Baſe, *o h* the Perpendicular, and *h z* the Hypothenuſal. Then the Angle *z o h*, contains 90 Degrees, which is the Meaſure of a right Angle.

A o x, is an acute Angle, containing leſs than 90 Degrees.

A o y, is an Obtuſe Angle containing more than 90 Degrees,

'Tis no matter of what Length the Lines of an Angle be; 'tis their meeting one another in a Point that forms the Angle, for the Angle *z o h*, contains 90 Degrees, and *a o c*, contains 90 Degrees alſo.

Let the Circle *Fig.* 13. repreſent the Limb of the Theodolite, and let the Index be brought to the beginning of the Numbers at *z*, then the Teleſcope which moves therewith, will be ſet in the Direction of *o a*: Now move the Teleſcope till it be in the Direction of *o x*, ſo ſhall the Index on the Limb ſhew the Number of Degrees of the Angle *a o x*.

Let *x o*, and *o y*, repreſent two Station Lines in the Field, then the Center of the Theodolite being planted over the angular Point *o*, let the Teleſcope be directed to *x*, (the Index being brought to the beginning of the Numbers on the Limb at *o*) and the Inſtrument fix'd there: Now move the Teleſcope till you ſee *y*, ſo ſhall the Index ſhew the Quality of an Angle *x*, *o*, *y*, on the Limb, 119 Degrees.

In working with the Theodolite we only meaſure the Length of the Lines, and Quantity of the Angles in the Field, which we note in a Field-Book for that Purpoſe; and by theſe Directions we may draw the exact Plan of the Land, which is call'd Protracting.

Provide a Field-Book rul'd with three Columns, in the middle Column inſert the Quantity of the Angles, and Length of the Station Lines; in the outer Columns the Offsetts from the Station Lines to the Bounders, and on each Side note the Remarks which you meet with in the Survey.

SECT. III.

Shewing the Uſes of the Theodolite in meaſuring the Angles round any Field or other Piece of Land.

The Theodolite before mention'd is numbred on the Limb, from the Left to the Right, and the Box from the Right to the Left; and therefore the Circuit is moſt conveniently made (according to the common Phraſe) *contra ſolem*. i. e. with the Fences on the right Hand.

Let *Fig.* 14. repreſent a Field of which a Plott is deſired: Firſt, chuſe ſome convenient Place therein, to begin the Work as at ⊖, near the Corner of the Field *a*, and ſet up a Staff with a Mark thereon, as a Piece of Paper, or a white Rag, ſo that you may plainly ſee it at the next Station; then lay the Chain in a ſtrait Line from *a* towards *b*, having firſt ſet up a Staff at *b*.

The Chain lying in this Direction on the Ground, meaſure with the Offset Staff from ⊖, the Diſtance to the Hedge 56 Links, and enter in the middle Column of the Field Book *o*, and in the right Hand Column 56, denoting an Offſett laid off from ⊖, 56 Links to the right Hand of the Station Line.

Meaſure forwards on the Station Line *a b*, till you come againſt the next Bend in the Hedge, then let the Chain lye on the Ground in a right Line between the Stations *a*, and *b*, and with the Offset Staff, meaſure the Diſtance from the Chain to that Bend in the Hedge 140 Links.

Take notice at what Length of the Station Line each Offset is laid off; as here at the Length of 540 Links on the Station Line, I lay of an Offset of 140 Links, therefore in the middle Column of the Field-Book that repreſents the Station Line enter 540, and againſt it in the Column on the right Hand, write 140, denoting that at the Length of 5 Chains 40 Links in the Station Line, you laid of an Offset to the right 140 Links.

Alſo take Notice that theſe Offsets are to be meaſured from the Station Line to the Hedge or Bounder, in ſuch Manner that the Line repreſenting the Offset may ſtand at right Angles with the Chain or Station Line, as the Line *o c*, with *z d*. *Fig.* 13.

Here I would adviſe a young Beginner in this Art, not only to enter theſe Obſervations in the Field-Book, but alſo on a Piece of waſte Paper, to draw firſt a Line that ſhall repreſent the preſent Station Line, and then upon that, to ſet of the Offſets as he meaſures them in the Field, drawing the Bounders as he goes along, not regarding the Length of any Line, a reſemblance of each Line being ſufficient; becauſe the true Lengths are entered in the Field-Book; for laying this Sketch before him, when he protracts his Work, he will find it an uſeful Inſtruction, in drawing his Angles inward or outward, and laying the Corners of the Field in their true Poſition, with other little Difficulties to be met with in Practice; but when he is accuſtom'd to a right Method of keeping the Field-Book this Trouble will be ſpar'd.

I proceed to meaſure on the Station Line to the next Bend in the Hedge, and there lay of an Offset at 8 Chain 26 Links, therefore againſt 826 in the middle Column of the Field-Book; write in the next Column on the Right; 36 Links the Length of the Offset.

The Hedge continuing ſtreight to ⊖ 2, meaſure up thereto, and enter the Length in the Field Book 1120, and meaſure the Diſtance to the Hedge 36 Links, which enter in the Column of Offsets againſt 1120, and draw a Line croſs the Field-Book.

Now remove the Staff from *b*, and cauſe it to be ſet up in a convenient Place, as at *c*, then plant the Center of the Theodolite exactly over the Hole, in which the Staff ſtood at *b*, by the help of the String and Plummet, as directed in the Uſe of the plain Table, making the Staves of the Inſtrument to ſtand firm on the Ground, then bring the Index to 360 on the Limb, and turn the whole Inſtrument about till the Hair in the Sights cuts the Staff at *a*, and there Screw it faſt, that the Motion of the Index may not cauſe it to ſtirr from this Poſition; then turn the Index about till the Hair in the Teleſcope cuts the Staff at *c*, ſo ſhall the Index ſhew the Quantity of that Angle *a b c*, on the Limb, *viz.* 102 Degrees 20 Minutes, which note in the Field-Book for the Quantity of that Angle.

Now for certainty that you have meaſured this Angle Right, you may turn the Teleſcope back to the Staff at *a*, and if the Hair cuts it you are right, otherwiſe not.

Having meaſured this Angle, let the Staff be brought from *a*, and place it in the Hole, over which the Center of the Inſtrument was poſited at *b*, but leave ſome Remark at *a*, that you may find it again when you come round the Field to cloſe the Plott: and lay the Chain from *b*, towards *c*, and at ⊖, meaſure the Offset to the Hedge 20 Links, at 236, in the Station Line, I lay of the Offset 36, at 428 in the Station Line, the Offset is 92, and at 796 the End of the Line, the Offset is 30, to the Corner, therefore againſt 30 in the Column of Offsets, write Corner, denoting that Offset laid of at Right Angles from the Station Line, reach'd the Corner of the Hedge.

Place the Inſtrument at *c*, and as before directed, meaſure the Angle *b c d* 110 Degrees 40 Minutes, which note in the Field Book for the Quantity of the Angle at *c*.

When you have meaſured the Angles, and made the neceſſary Obſervations at each Station draw a Line croſs the Field Book as you will ſee in the Form thereof, alſo take notice that the Minutes are eſtimated by the help of *Nonus*'s Invention which can't be ſo well deſcrib'd as by the Sight of the Inſtrument; only this may be ſaid, that we can thereby eſtimate the Quantity of an Angle to 2 or 3 Minutes, which is as exact as they can be laid down on Paper by the Protractor.

Bring the Staff from *b*, and ſet it as upright as you can at *c*, and ſend another forwards to *d*, then meaſure on the Line *c d*, and lay of the Offset to the Corner at 434, and againſt that Offset write Corner in the Field-Book, and meaſure up to *d*, entring the Length 468 in the Field-Book.

Plant the Inſtrument at *d*, and bring the Index to 360 on the Limb, and turn it about till the Hair in the Teleſcope cuts the Staff at *c*, and there fix the Inſtrument, and then direct the Teleſcope to *e*, and note the Quantity of the Angle at *d*, which the Index cuts on the Limb, *viz.* 230 Degrees 50 Minutes, which note in the Field-Book for the Quantity of that Angle.

But no Angle is greater than 180 Degrees, therefore if you would know the true Quantity of this Angle, ſubtract 230 Degrees, 50 Minutes, from 360 Degrees, the Remainder is 129 Degrees 10 Minutes, the true Quantity of that Angle.

Note, When you meet with an outward Angle, remember to Mark it in the Field-Book with >, or ſome ſuch Mark, as a Direction when you come to protract this Angle; to draw it outwards as it is in the Field.

In the ſame Manner deal with the reſt of the Lines and Angles round the Field, till you come to Station *a*, but there is no neceſſity to meaſure the laſt Angle, or the two laſt Lines, unleſs it be to prove the Truth of the Work, which indeed is convenient.

When the Inſtrument was planted at *f*, and you had meaſured the Quantity of that Angle, the Inſtrument remaining in the ſame Poſition, if you direct the Teleſcope to the Tree in the Middle of the Field, and note the Degrees, *&c.* which the Index cuts on the Limb, and the ſame at *g*, and note theſe Degrees, *&c.* in the Field-Book, in the Column of Remarks, you may protract the true Situation of the Tree in reſpect of any other Part of the Field.

See the Form of theſe Obſervations as noted in the Field-Book.

The

The Field-Book.

Remarks	Offsets	Station Lines	Offsets	Remarks
		a Θ1		

		0	56	
		540	140	
		826	36	
		1120	36	
		b Θ2		
		° '		
	Angle	102.20		

		0	20	
		236	36	
		428	92	
		796	30	*Corner*
		c Θ3		
		° '		
	Angle	110.40		

		434	30	*Corner*
		468		
		d Θ4		
		° '		
	Angle	230.50		

		420	30	

The Field-Book Continued.

Remarks	Offsets	Station Lines	Offsets	Remarks
		e Θ5		
		°		
	Angle	79.00		

		0	40	
		134	36	
		296	33	
		588	100	
		820	12	
A Tree bears *from* Θ 6 ° ' 38. 30		f Θ6		
		° '		
	Angle	84. 30		

		40	120	*Corner*
		200	24	
		706	16	*Corner*
Tree bears *from* Θ7 ° ' 57. 30		g Θ7		
		°		
	Angle >	233		

		380	80	
		648	40	

SECT. IV.

The next Thing to be done, is to protract the Obſervations made in the Field, *Fig.* 14. ſo that the ſeveral Lines and Angles therein, may be laid down on Paper of the ſame Length, and in the ſame Direction as in the Field it ſelf. In proportion as the Scale we make uſe of is to the Chain.

The Protractor generally uſed, is a Semicircle, though a whole Circle is better. Numbred and divided in the ſame manner as the Limb of the Theodolite, which it ſhould always be; the Protractor being eſteem'd an Epitome of Inſtruments.

But becauſe the Degrees on the Protractor, are ſo much ſmaller than thoſe on the Limb of the Theodolite, they can't be well eſtimated nearer than 10 Minutes; yet if any one will be curious, he may lay down the Angles on the Paper, to a Minute or two as exactly as they can be obſerved in the Field.

Mr. *Ward's* Protractor being commonly uſed for this Purpoſe, is made with an Index to move on the Center of the Semicircle, which Index is divided into 2 Parts, ſo fram'd, that each may be the Diagonal of one Degree; ſo that if the diſtance at the extream Ends be 10 Degrees, that next the Limb muſt be 8 Degrees, the Space between the two Limits in each Diagonal being divided into 60 Parts or Minutes; but theſe Diviſions will be very unequal, being thoſe of the Tangent Line, which fall near Infinite.

Mr. *Siſſon* hath removed this Inconveniency, by making each Edge the Arch of a great Circle paſſing through the Center of the Protractor; the Space between the firſt and laſt Diviſions being two Degrees thereof, and is divided into 60 equal Parts or Minutes.

The Reaſon depends on the 27 *Prop.* of the 3*d*, of *Euclid*, *viz.* That the Angle at the Center of a Circle is double to that at the Circumference.

The ſame Perſon hath contrived another Protractor, to lay down Minutes without any Index at all, and therefore preferable to both the former, becauſe 'tis exceeding difficult to make the Index move exactly round the Center, and if it ſhakes the leaſt that can be, the Inſtrument is uſeleſs; but this laſt is made of one Piece of Braſs, and may be us'd as a common one, without regarding the Minutes when Expedition is requiſite.

It may be thought here are too many Words ſpent about deſcribing theſe Protractors as well as the Theodolite before mentioned; but if any one pleaſes to conſider, that if we be not very exact in meaſuring the Angles in the Field, and laying them down in the ſame manner on Paper, (which is impoſſible to be done without good Inſtruments) we ſhall commit very great Miſtakes; for Inſtance, If I miſtake half a Degree in the meaſuring of an Angle, one of whoſe Sides is 20 Chains, the Area or Content of that Piece of Ground ſo left out or added to the Plott, by drawing this Line in a falſe Poſition, will be above 23 Poles; and this Error communicated to the following Work, will be very conſiderable in the whole.

SECT. V.

The Manner of Protracting the aforegoing Obſervations.

AS the Lines are meaſured in the Field by the Chain, and the Angles by the Limb of the Theodolite, ſo the Lines are laid down on the Paper by the Scale, and the Angles by the Protractor.

Provide a Skin of Parchment, if the Plott is deſired to be on Parchment, according to the largeneſs of the Work you are about to lay down; or if on Paper, let it be large enough to hold all your Work; the ſtrong Cartridge Paper for this Purpoſe is accounted beſt by ſome Surveyors.

Having conſidered which way the Plott will extend, draw an obſcure Line on the Paper to repreſent the firſt Station Line, and mark the End thereof with ⊖ *a*, ſo ſhall that Point repreſent the firſt Station in the Field, and cloſe to this obſcure Line, lay the edge of your plotting Scale, the beginning of the Numbers coinciding with ⊖ *a*, and encreaſing towards the next Station; then lay the Field-Book open before you, and becauſe the offsets in the firſt Length are taken at the Diſtances 0, 540, 826, 1120; therefore againſt theſe Numbers on the Scale, make Marks in the obſcure Line, cloſe to the edge of the Scale.

This done, turn the Scale perpendicular to the obſcure Line, ſo that the ſeveral offsets may ſtand thereon at right Angles as aforeſaid, and apply it ſucceſſively to theſe ſeveral Points, and there Prick off the Length of the ſeveral offsets on the ſame Side of the obſcure Line as noted in the Field-Book; ſo at ⊖ I prick off 56 at 500, the next Length I prick off 140, at the next Point, which is at the Length 826, I prick off 36, and at 1120 the End of the Line, I prick off 36.

Now if Lines are drawn from Point to Point, they ſhall repreſent the Bounders of this Side of the Field; and becauſe the Hedges, eſpecially in old Encloſures, are generally in the Form of a curve rather than ſtrait Lines, therefore if you draw the Bounders from Point to Point with a Quill-Pen with your Hand only, they will be more naturally expreſs'd, than if you lay a ſtrait Ruler from Point to Point, (except the Diſtances are very long, or you take a multitude of Offsets;) and to be exact, 'tis ſometimes neceſſary to expreſs the Nature of theſe little Irregularities in the Fences, by a Sketch on one Side of the Field-Book; but if you will be very curious, you may have an Inſtrument in Form of a Steel-Bow, which by the help of Screws may be drawn in any curve Form, and by this the Bounders may be readily drawn.

The Length of the firſt Station Line being 1120, mark that Diſtance from ⊖ *a*, with ⊖ *b*, and let the obſcure Line be produc'd, each way as long as the Radius of the Protractor.

Lay the Center of the Protractor to the Point ⊖ *b*, and turn it about thereon, till the Diameter lyes on the Line ⊖ *a*, ⊖ *b*, the beginning of the Numbers on the Protractor being laid towards ⊖ *a*, contrary to the Theodolite in the Field.

Hold the Protractor cloſe down to the Paper in this Poſition, and becauſe the Angle at *b*, is 102 Degrees 20 Minutes, therefore with a Protracting Pin or Needle, make a Mark againſt 102 Digrees 20 Minutes, cloſe to the Limb of the Protractor, through which Mark from *b*, draw the obſcure Line *b c*.

So is the Station Line *b c*, laid down in the ſame Direction as in the Field, and the Angle *a b c*, the ſame.

Lay the Plotting Scale to the obſcure Line *b c*, the beginning of the Numbers coinciding with the preſent Station, and the Numbers encreaſing towards the next, then cloſe to the edge thereof, againſt 0, 236, 428, 796, the Lengths where the Offsets were taken, make Marks with the Protracting Pin, and turn the Scale perpendicular to the obſcure Line, and Prick off the ſeveral Offsets, 20, 36, 92, 30.

And now if Lines are continued from the Fences before drawn to theſe Offsets, they ſhall repreſent the Bounders on this Side of the Field.

The Offset at the End of the ſecond Station Line, at *c*, reaches into the Corner, but thoſe at *b* muſt be continued till they meet one another, and this might be expreſſed in the Field-Book or Sketch, that you may not miſtake the Corner of the Field.

Lay the Center of the Protractor to *c* the Diameter, held cloſe to the Line *b c*, and againſt 110 Degrees 40 Minutes on the Limb of the Protractor, make a Mark, through which draw the Line *c d*.

At the Length 434, in this Line lay of the Offset 30 Links, to which continue the Bounders before drawn, ſo is this Side of the Field finiſhed.

Note, the next Angle at *d*, being noted in the Field Book, 230 Digrees 50 Minutes, you muſt either ſubtract 2°30 5'0, from 3°60 : '00 the Remainder is, 129 Degrees 10 Minutes for the true Quantity of that Angle; and becauſe 'tis marked External, it muſt be plotted outward, and the beginning of the Numbers on the Protractor muſt be laid the contrary way, *viz.* towards the next Station.

Or if the Protractor be numbred to 360, on a Circle concentric to the outward Circle, and the Numbers on both encreaſe the ſame way, (as the Limb of the Theodolite) then the Angle 230 Degrees 50 Minutes, may be pricked off from the inner Circle.

But if you uſe a circular Protractor, it may be laid always one way, *viz.* the beginning of the Numbers towards the laſt Station, contrary to the Theodolite in the Field, and this in my Opinion is the beſt Way.

But if you uſe a ſemicircular Protractor, obſerve to lay the Diameter on that Line which brought you to the preſent Station, and to lay the beginning of the Degrees of the Protractor towards the laſt Station when the Angle is leſs than 180 Degrees, but the contrary way when the Angle is more.

So at *d*, lay the Diameter of the Protractor on the Line *c d*, the beginning of the Numbers being laid the contrary way to *c*, and againſt 230 Degrees 50 Minutes on the inner Circle of the Protractor, make a Mark, through which draw the Line *d e*.

In the ſame manner lay down the Angle at *e*, and draw the Line *e f*, continuing the Bounders as before directed.

When you have marked the Angle at *f*, let the Protractor lye in the ſame Poſition, and make a Mark againſt 38 Degrees 30 Minutes, as noted in the Field-Book for the bearing of the Tree from that Station, and through that Mark draw an obſcure Line from *f*.

Do the ſame at *g*, continuing the obſcure Line from thence till it croſſes that drawn from *f*, ſo ſhall the Interſection of theſe two Lines determine the Scituation of the Tree in the Middle of the Field.

In the ſame manner may any other inacceſſible Diſtance be meaſured by the Theodolite.

When you have Marked the Angle at *g*, and drawn the Line *g a*, it will cut through the Point *a*, and the Length of the Line *g a*, will be the ſame as that noted in the Field-Book, and the Angles at *g*, and *a*, (if you had meaſured it) the ſame which proves the Plott to be truly laid down.

SECT. VI.

IT may not be improper to take notice in this Place, of the Method propoſed by ſome Authors, as a Proof that the ſeveral Angles in a Field are truly meaſured, by collecting the Quantities of all the Angles into one Sum, and then to multiply 180, by a Number leſs by two than the Number of the Angles in the Field; and if the Product of this Multiplication be equal to the total Sum of the Angles, the Work is concluded to be right.

But theſe two Numbers may agree, and yet a Miſtake may be committed in meaſuring the Angles; as for Inſtance:

Let the Number of Angles in the Field be 7, and the Quantities collected into one Sum be 900; then multipling 180, by a Number leſs by two than the Number of the Angles, *viz.* 5, the Product is 900, equal to the Sum of the Angles.

Let the true Quantity of the firſt Angle be 160 Degrees, and the true Quantity of the Second 190 Degrees; theſe two Numbers when added together make 350; but ſuppoſe you had made a Miſtake in eſtimating the Degrees on the Inſtrument, or noting them in the Field Book, and for the Firſt Angle had noted 190 Degrees, and for the Second 160 Degrees, their Sum will ſtill be 350; ſo that by this Method you will not diſcover your Error; but hereafter will be inſerted a Method, whereby an Error may be corrected at every Station in the Field before we leave it by the help of the Needle and Limb together, but firſt I proceed to ſhew the Uſe of the Needle only in ſurveying Land.

SECT. VII.

Of the Circumferentor.

THE Circumferentor is an Inſtrument uſed to meaſure Angles in the Field; it conſiſts of a Box and Needle, ſcrewed to the Index with plain Sights thereon, or inſtead of the plain Sights with a Teleſcope mounted over the Box, that may be either elevated or depreſſed to an Object as there ſhall be occaſion; the Index is mov'd by a Ball and Socket, and ſupported by a three legged Staff.

In Surveying Harbours, Seacoaſts, Counties or large Commons, where the Lines are very long, or thick over grown Woods, where we may be forced to make a multitude of Angles, and the Sight of the two Lines conſtructing the Angle, may be hindred by the Bruſh or Underwood; in theſe Caſes the Angles may be meaſured ſufficiently exact by the Needle only, (though better, and as quick by the Theodolite, as will be ſhew'd hereafter) yet in ſurveying Lordſhips, Encloſures, or plain Paſture Land, (a ſmall piece of which got or loſt is of a conſiderable Value, and each particular Field ought to cloſe exactly) the Angles are without doubt more ſurely meaſured by the Limb of the Theodolite, becauſe the Degrees in the Box can't be ſo nearly eſtimated, and the Needle is liable to be drawn aſide by ſome hidden magnetick Power.

The Poſition or bearing of a Line obſerv'd by the Needle, is expreſſed by ſuch a Number of Degrees and Minutes as it is diſtant from, or Quantity of the Angle, which that Line makes with the Meridian.

And if a Perſon wholly unacquainted with the uſe of this Inſtrument, will take the Pains to try this following Method, it may be an help to conceive the manner of uſing it in the Field.

Upon a Sheet of Paper let there be drawn right Lines parallel one to another at any Diſtance, and upon a Table let there be fixed a Pin with the Point upwards, let the Pin ſo fixed, be run through one of the Lines in the Paper, and upon the Point of the Pin, let there be put a Magnetick Needle, let it traverſe about till it reſts of it ſelf; then turn the Paper about on the Table till the Needle hangs directly over the Line, in which the Pin is placed, which is diſcovered by fixing the Eye over its center; then with ſealing Wax faſten the Paper to the Table by the four Corners; ſo may the Paper be ſuppoſed to repreſent the Surface of the Earth, and the Lines the magnetick Meridian (which mark at the top with North, and at the bottom with South.)

For if the Pin be removed into any other of the Lines, and the Needle be made to traverſe thereon, it will, when at reſt, hang directly over the Line in which the Pin is placed, if it be drawn parallel to the firſt Line, over which the Needle hung when the Paper was fixed.

The Needle then points always to or lyes in the direction of the Meridian, by virtue of the magnetick Power; ſo if I had faſtened to the Table a Sheet of blank Paper, and had laid a Ruler in the ſame direction with the Needle when at reſt, and had drawn a meridian Line, and removed the Needle to another part of the blank Paper, and drawn another ſuch a Line by the direction of the Needle, that would have been a Parallel.

When we take an Angle in the Field by the Needle, the meridian Line is always one ſide of the Angle, and the Hedge Wall or Fence along which the Teleſcope is directed, is the other ſide of the Angle, and they are ſuppoſed to meet at the Center of the Inſtrument.

But with the Theodolite, the Angle is formed by the meeting of the two Lines or Fences themſelves.

Set one Foot of a Pair of Compaſſes in ſome one of the Meridians on the Paper, and deſcribe a Circle, then the Line is its Diameter: Divide this Circle into 360 Degrees, which is eaſily done by the Protractor, and let the Numbers begin at N. or North, and encreaſe to the left, towards E or Eaſt.

Then this Circle repreſents the Box of the Inſtrument in the Field, and the Line N. S. repreſents the Needle.

From the Center of the Circle, draw a long Line any way at a venture, and imagine this Line repreſents an Hedge or Station-Line in the Field, and to find its bearing or Angle that it makes with the meridian, look what Degreee, *&c.* it cuts on the Circle, for that is the Quantity of the Angle or Number, expreſſing its bearing, counted from the beginning of the Numbers.

So the Needle uſed in the Field points out the magnetick Meridian, and the Diviſions in the Box mov'd under it meaſure the Angle, that any Line in the Field makes with that Meridian.

The Box of the Circumferentor is commonly numbred from the right to the left; the Numbers beginning at N or North, which is mark'd alſo with a Flower de luce, and encreaſe towards E or Eaſt, and the direction is to be taken from the North end of the Needle.

Let it be required to obſerve the bearing of the ſeveral Station-Lines that encompaſs the Wood, *Fig.* 15.

SECT. VIII.

The Uſe of the Circumferentor in Surveying Land.

FIrſt plant the Circumferentor at ſome convenient Station as at *a*; the Flower de luce in the Box being from you, direct the Sights to a Mark at the next Station *b*, and mark the Diviſion which the North end of the Needle points to in the Box when at reſt, which is 260 Degrees 30 Minutes; therefore note this Number 260 Degrees 30 Minutes in the Field-Book, for the bearing of the Line *a b*.

Obſerving former Directions for removing the Inſtrument from one Station to another, and meaſuring the Station-Lines and Offsets from thence to the Bounders as you paſs along the Station-Lines, let the Inſtrument be removed from *a*, and planted at *b*, the next Station; then keeping the Flower de luce in the Box from you; turn the Inſtrument about till the Hair in the Sights cuts a Mark at the next Station *c*; then will the North end of the Needle point to 292 Degrees 12 Minutes, which note in the Field-Book for the bearing of the Line *b c*.

The Inſtrument planted at *c*, and the Sights directed to d, the bearing of that Line *c d* will be 331 Degrees 45 Minutes.

In the ſame manner proceed to take the bearing of the other Lines round the Wood, obſerving this general Law.

To keep the Flower de luce in the Box from you, and to take the bearing of each Line from the North end of the Needle.

The Numbers in the Card of ſome of theſe Circumferentors are made to encreaſe towards the right, but that before mentioned is beſt; for when you turn your Inſtrument to the Eaſtward, the Needle will hang over the Weſtward Diviſion on the contrary Side.

Inſtead of planting the Circumferentor at every Station in the Field, the Bearings of the ſeveral Lines may be taken if it be planted only at every other Station.

So if the Inſtrument had been planted at *b*, and the Flower de luce in the Box kept towards you when you look back to the Station *a*, and from you when you look forwards to the Station *c*, the Bearings of the Lines *a b*, and *b c*,, would be the ſame as before obſerved; alſo the Bearings of the Lines *c d*, and *d e*, might be obſerved at *d*, and *e f*, and *f a*, at *f*; ſo that inſtead of planting the Inſtrument 6 times, you need in this caſe plant it but 3 times, which ſaves ſome Labour.

But ſince you muſt go along every Station Line, to meaſure it or ſee it meaſured, the trouble of ſetting down the Inſtrument is not very great, and then alſo you may examine the Bearing of each Line as you go along; and if you ſuſpect an Error in the Work by the Needles being acted on by ſome hidden magnetick Power, or from your own Miſtake, in obſerving the Degrees that the Needle points to, you may correct ſuch Error at the next Station before you proceed.

As when the Inſtrument was planted at *a*, and the Sights directed to *b*, the Flower de luce from you, the North end of the Needle pointed to 260 Degrees 30 Minutes; now being come to *b*, direct the Sights back to a Mark at *a*, keeping the Flower-de-luce towards you: So ſhall the North end of the Needle Point to 260 Degrees, 30 Minutes, as before at *a*, and then you may be ſure the bearing of the Line *a b*, is truly obſerved.

But if the Needle doth not point to the ſame number of Degrees, *&c.* there hath been ſome

Error in that Obſervation, which muſt be corrected before you proceed.

If you have a ſuſpicion that the Needle doth not play well, when the Inſtrument is planted at any Station, as at *a*, direct the Sights to the Mark at *b*, and note the Degrees, *&c.* pointed at by the Needle in a piece of waſte Paper; then with a clean Knife, Key, or any bit of poliſh'd Steel, that hath touched a Loadſtone, move the Needle by applying it to the Box, and examine when it hath ſettled again what Degrees it then Points at, the Sights being ſtill directed to the preceding Mark at *b*; and if the Degrees are the ſame, they may be entred in the Field-Book, but if not, the Cap and Pin muſt be cleanſed with ſome brown Paper and a little Putty, and thereby freed from ſuch Duſt or Dampneſs that hath gotten to it; if after all the Needle does not play freely, place in the Box another Pin, or uſe another Needle, or do both, and theſe Neceſſaries a Surveyor ought to have in his Pocket while he is in the Field.

If you would meaſure the Quantity of any Angle by the Needle, place the Inſtrument at the angular Point, and take the Bearing of the two Lines conſtructing that Angle, and ſubtracting the leſſer out of the greater, the Remainder is the Quantity of that Angle, if leſs than 180 Degrees, but if the Remainder is greater than 180 Degrees, ſubtract it out of 360 Degrees, and that laſt Remainder is the Angle.

The manner of entring the Offsets in the Field-Book, is before ſhewn in the uſe of the Theodolite; it will be ſufficient in this place, to inſert the Bearing of each Line or Quantity of the Angle, which each makes with the Meridian, together with their Lengths, in order to protract or lay them down on the Paper Plott of the ſame Length and in the ſame Direction as in the Field. *Vide Fig.* 15.

SECT. IX.

The manner of Protracting the aforegoing Obſervations made by the Circumferentor.

Lines	Bearings	Links
a b,	260 30	1242
b c,	292 12	1012
c d,	331 45	1050
d e,	59 00	1428
e f,	112 15	645
f a,	151 30	1806

Firſt, draw Lines parallel to one another quite through the deſigned Draught, at Diſtances not exceeding the Breadth of the diametrical Part of your Protractor, as in *Fig.* 15, and mark them with N, and S, for North and South; then conſidering which way the Plott will extend, aſſign a Point in ſome one of the parallel Lines, to repreſent the firſt Station in the Field, as at *a*, to which Point lay the Center of the Protractor, and by the help of the Diviſions continued beyond the Ends of the Diameter of the Protractor, lay the Diameter upon, or parallel to thoſe North and South Lines; the beginning of the Numbers on the Protractor towards that part of the Line mark'd with N, or Northwards, when the Degrees are fewer than 180, but Southwards when more; the Protractor thus placed, look in the Field-Book for the Bearing of the firſt Line *a b*, which is 260 Degrees 30 Minutes; therefore with the beginning of the Numbers on the Protractor towards *ſ*, cloſe to the Limb againſt 260 Degrees 30 Minutes make a Mark, and through that Mark from the aſſigned Point at *a*, draw a Line *a b*, on which Line ſet 12 Chains 42 Links, as noted in the Field-Book.

So will the Line *a b*, on the Paper, have a Bearing like to that, which you obſerved the Line *a b* to have in the Field, in reſpect of the Meridian, but the Protractor to lay down theſe Obſervations muſt be numbred contrary to the Box of the Circumferator; and if it be a Semicircle it muſt be numbred, firſt to 180, and then on the inner Circle whoſe Numbers muſt encreaſe the ſame way as the outer Circle to 360, and the Bearings greater than 180, are pricked off from this inner Circle, and the beginning of the Numbers muſt be laid Northward or Southward as the Degrees of Bearing are more or leſs than 180; but if your Protractor be a whole Circle, the beginning of the Numbers may be kept always one way, as the Numbers of the Circumferentor were in the Field, (the Protractor being an Epitome of the Inſtrument you make uſe of in the Field) but the Diameter muſt be always laid upon a Parallel to the meridian Lines, and may be mark'd with N S at the Ends as a Direction to keep it in its true Poſition.

Having made the Line *a b* of its true Length and Poſition, the next thing to be done is to lay of the Offsets therefrom, which gives the Bounders of that ſide of the Wood, *Fig.* 15.

Lay the Center of the Protractor to the Point *b*, and becauſe the Bearing of the Line *b c*, is more than 180, lay the beginning of the Numbers of the Semicircular Protractor towards S, and againſt 292 Degrees 12 Minutes, make a Mark, through which Mark from *b*, draw the Line *b c*, ſetting of the Offsets therefrom, and draw the Bounders of that ſide of the Wood.

In the ſame manner lay down the other Lines *c d*, *d e*, *e f*, and *f a*; ſo will the Line *f a*, cut through the Point *a*, and be of the ſame Length on the Plot as that meaſured in the Field, if the Obſervations be truly made.

Then if you drew the Station-Lines, and Off-ſets with a black-lead Pencil, and the Bounders with Ink; you may with a piece of Bread rub off thoſe Lines, ſo ſhall the true Bounders of the Wood only remain, which gives the exact Figure thereof.

SECT. X.

The manner of caſting up the ſmall irregular Pieces of Ground, which lye between the Station Lines and Hedges.

IT very rarely happens that the ſides of a Field are all ſtrait Lines, and therefore any Method for meaſuring them from one or more Stations in the Middle, can ſeldom be put in Practice; the beſt way being to go round, and meaſure the ſeveral Angles from Stations near the Bounders, but at ſuch a Diſtance from thence that we may ſee clearly from one Station to another, and have plain Ground to meaſure the Diſtances, free from the Incumbrance of bruſhwood, Trees, &c. ſo ſhall the greateſt Quantity of the Land be included between the regular Station-Lines, which is caſt up as before directed by dividing the ſame into the largeſt Trapezias and Triangles that may be, and meaſuring the Baſes and Perpendiculars by the ſame Scale that the Plott was laid down by.

But in order to caſt up the ſmall irregular Pieces comprehended between the Station-Lines and Bounder; if you reduce them into Triangles,

&c. as they will be a great many in Number, ſo you will very much err in laying of them down firſt, and taking them off afterwards, eſpecially if the Scale you protract by, be very ſmall, where 10 or 12 Links of a Chain is hardly to be eſtimated though the Scale be well divided, and the Points of the Compaſſes very fine: For the removal of this Inconvenience, I ſhall here ſhew a way whereby you may caſt up theſe ſmall Quantities, let the Scale be never ſo ſmall, as exactly as any of the greater parts of the Field.

Suppoſe the ſmall irregular Pieces between the Station-Lines and Bounders, *Fig.* 14, were to be caſt up.

First lay the Field-Book before you, where you will find the Length of the firſt Offset (as meaſured in the Field with your Offset Staff) from ⊖ 1 at *a*, to be 56 Links, and the ſecond at 540, in the Chain-Line 140, forming the ſmall Trapezia, *a*, *Vide Fig.* 16.

Now if you add the Offset 56 to the next 140, the Sum is 196, the half of which is 98, the equated Breadth; multiply the Length 540 by 98, the Product is 52920, the content of the Trapezia, *a*, in ſquare Links.

Add 140 to 36, the Sum is 176, the half Sum 88, ſubtract 540 from 826, the Remainder is 286, the Length of the Trapezia, *b*; therefore multiply 286 by 88, the Product is 25168, the Content of the ſmall Trapezia, *b*.

Subtract 826 from 1120, the Remainder is 294, the Length of *c*; and becauſe both the Offsets are alike, multiply 294 by 36, the Length of the perpendicular Offset, the Product is 10584, the Content of the ſmall Piece, *c*.

In the ſame manner deal with the reſt of theſe ſmall Pieces round the Field, and ſet down the Product of each in an orderly manner one under another; ſo ſhall the Sum give the exact Content of theſe ſmall Pieces, which added to that within the Station Lines, gives the true Content of the Field in ſquare Links, which reduce into Acres, *&c.* as before directed.

Note, The Performance of this being tedious, I ſhall in the next Chapter lay down a more Practical Method for caſting up the Content of any Piece of Land.

CHAP. III.

Shewing the Uſe of the Theodolite in Surveying Land by the help of the Needle and Limb together.

SECT. I.

IN this Method of Surveying Land, the Angle which every Line makes with the Meridian is meaſured by the Limb of the Theodolite, and therefore much preferable to that before mentioned in the aforegoing Chapter by the Needle only, becauſe the Degrees and Minutes are better eſtimated on the Limb of the Inſtrument than 'tis poſſible they ſhould be in the Box of the Circumferentor; and this gives the Theodolite the preference to any other Inſtrument, becauſe we can work by the Limb only, without regarding the Needle at all; but if it be more convenient to make uſe of the Needle, we may do it in the following manner, being the moſt exact and abſolute Method yet known for Surveying large and ſpacious Tracts of Land.

For the Needle being obſerved to play well, when it hath ſettled in the direction of the Meridian and is at reſt, the Box may be moved round the fixed Center by turning the Index on the Limb and the Point mark'd with 360 in the Box, brought directly againſt the north End of the

Needle, with greater Exactneſs than a Degree, and its Parts can be eſtimated in any other Part of the Box; beſides we have this Advantage which is very conſiderable, that we can make uſe of a ſhort light Needle whoſe friction being leſs, plays better than a longer and heavier.

Let the Lines *o a*, *b c*, *d e*, *f*, in *Fig.* 17. repreſent the Station Lines near the Bounders of a Field; then the Angle which each makes with the Meridian may be obſerved in the following manner.

Firſt, having ſet up a Mark at *o*, Meaſure forwards with the Chain on the Line *o a* to *a* 600 Links.

Plant the Inſtrument at *a*, and bring the Index to 360 on the Limb, and turn the whole Inſtrument about (whilſt the Needle hangs in the direction of the Meridian) till 360 in the Box is brought directly againſt the north End of the Needle, and there fix the Inſtrument, then is the Teleſcope ſet in the direction of the Meridian alſo; and in this Poſition is the Inſtrument to be planted at every Station.

Now turn about the Index till the Hair in the Teleſcope cuts the Mark left at *o*, and note in the Field Book the Degrees and Minutes which the Index cuts on the Limb, *viz.* 207 Degrees 20 Minutes, being the Quantity of the Angle which the Line *a o* makes with the Meridian.

Remove the Inſtrument from *a*, leaving a Mark at that Station and proceed with the Chain to *b*, and there plant the Inſtrument, then bring the Index to 360 on the Limb, and 360 in the Box exactly to the north End of the Needle as aforeſaid, and direct the Teleſcope to the Mark left at *a*, and note the Degrees and Minutes cut on the Limb by the Index, *viz.* 285 Degrees 10 Minutes, which is the bearing of *b a* or Quantity of the Angle which that Line makes with the Meridian.

It would be Tautology to repeat the manner of meaſuring the other Lines and Angles in this Figure, but obſerve that when the Inſtrument is fixed in the direction of the Meridian, we frequently obſerve the Needle by moving it from the Point at 360 with a Knife, *&c.* then if it ſwings backward and forward freely without jogging or ſtopping, and ſettles again to 360 exactly; we may conclude the Inſtrument is right in the direction of the Meridian to make an Obſervation.

If you ſuſpect the Needle to be acted upon by ſome hidden magnetick Power, as when you are Surveying in mountainous Lands, where there may poſſibly be Iron Mines in the Earth, which will attract the Needle, you may obſerve whether or no it be drawn aſide in the following Manner.

As when the Inſtrument was planted at *e*, the *North* End of the Needle pointing to 360 in the Box; after the bearing of *e d* was noted, direct the Telleſcope forwards to *f*, and note the Angle which the Index cuts on the Limb; *viz.* 200° 5′0, then the Inſtrument being planted at *f*, becauſe the bearing of *e f*, obſerved at *e*, is more than 180°; ſubſtract 180 there-from and to the Remainder 2′0 5′0 on the Limb, ſet the Index exactly; but if the bearing of *e f* had been leſs than 180, add 180 thereto, and to that Number, being the Index on the Limb, now turn about the whole Inſtrument till the Hair cuts the Staff left at *e*, and then, if the *North* End of the Needle points to 360, as at the laſt Station, the Bearing of that Line is truly obſerved.

For the magnetick Power that attracts the Needle, being ſuppoſed at a great Diſtance, the Direction on ſuch a Piece of Land as is commonly ſurveyed by the Theodolite, will be the ſame: But if the attractive Power be near the Inſtrument, the Needle will incline thereto.

Now follows the manner of protracting theſe Obſervations,

Lines	*Links*		*Sta.*	*Deg.*	*Min.*
a, *o*,	600	———	*a*,	207	20
b, *a*,	500	———	*b*,	285	10
c, *b*,	1000	———	*c*,	190	00
d, *c*,	500	———	*d*,	91	55
e, *d*,	500	———	*e*,	125	20
f, *e*,	1600	———	*f*,	20	50
o, *f*,	500	———	*o*,	289	15

SECT. II.

A new Method of protrocting any Obſervations made in the Field by the Needle.

BY which a Plan may be drawn on the Paper from one Meridian only, and all the Angles therein laid down by once applying the Protractor to that Meridian by the help of a parallel Ruler, being very exact and expeditious.

Provide a circular Protractor, whoſe Numbers encreaſe the ſame way as on the Limb of the Theodolite, and a parallel Ruler of a convenient Length, then draw a Right-line N S, *Fig.* 17. (with a black lead Pencil) for a Meridian, and aſſign a Point therein, as at *o*, to which Point apply the Center of the Protractor, and turn it about till the Diameter lyes on the Line N S, with 180 towards N, (that part of the Limb of the Theodolite being always kept Northward of the Field.)

The Protractor held in this Poſition, lay the Field Book before you, and againſt 207 Degrees 20 Minutes, the bearing of the Firſt Line *a o* cloſe to the Limb of the Protractor, make a Mark with the protracting Pin or Needle, and cloſe to that Mark write *a* with a black lead Pencil.

Hold the Protractor in the ſame Poſition, and againſt 285 Degrees 10 Minutes, the bearing of the next Line *b a*, make a Mark with the protracting Pin, and cloſe to that Mark ſet *b*.

In the ſame manner keeping the Diameter of the Protractor cloſe to the Meridian as it was at firſt laid; make a Prick with the protracting Pin, cloſe to the Limb of the Protractor, againſt the bearing of each reſpective Line as noted in the Field Book, and cloſe to each Prick ſet the Letter or Number of that Line; ſo againſt 190 Degrees the bearing at *c*, make a Prick and write *c*, againſt 91 Degrees 55 Minutes write *d*, againſt 125 Degrees 20 Minutes write *e*, *&c. Vide Fig.* 17.

Having mark'd the bearing of each Line round the Protractor, lay it aſide, and apply the edge of your plotting Scale to *o* at the Center, and *a* mark'd by the Limb of the Protractor; the beginning of the Numbers coinciding with *o*, and encreaſing towards *a*, and prick off 6 Chains the Length of the Line *o a*, and with Ink draw the Line *o a c*.

Lay the parallel Ruler to the prick'd Line *p o b r*, ſo that the edge cuts the central Point at *o*, and the Point at *b*, as mark'd by the Limb of the Protractor; and move it parallel till the Edge cuts the Point at *a* in the Line *p a b r*, and with the Point of your Compaſſes draw the occult Line *p a b r* by the Edge of the parallel Ruler; then becauſe the Length of the Line *a b* is 5 Chains, lay the plotting Scale to *a* and Prick off 5 Chains, and draw the Line *a b*.

When you had drawn the occult Line *p a b r*, through the Point *a*, you might ſet *a b* thereon towards *p* as well as towards *r*; but if you obſerve in what Direction the Letter *b*, as mark'd by the Limb of the Protractor, ſtands from the central Point *o*, in the ſame direction muſt the Line *a b* be ſet from the Station Point *a*; alſo when the Ruler is laid to the Station *b*, you cannot be at a loſs whether you ſhould draw the Line *b c* upwards or downwards, if you obſerve in what direction the Letter *c* ſtands from the central Point *o*; therefore in the ſame Direction draw *b c* from *b*, or the Angles mark'd external in the Field Book will be a ſufficient Direction.

Lay the parallel Ruler to the central Point *o*, and the Mark at *c*, and move it parallel in that Direction, till the Edge cuts the Point *b* at the end of the Line *a b*, and by the Edge of the parallel Ruler, draw an occult Line, ſetting thereon from *b* 10 Chains, and draw the Line *b c*.

Again lay the Edge of the parallel Ruler to the Point at the Center *o*, and to the Mark at *d*, and move it up to *c*, and draw *c d*.

In the ſame manner deal with the other Lines and Angles, ſo ſhall the laſt Line *f o* cut through the Point *o*, and its Length be 5 Chains, as noted in the Field Book, which proves the Plott to be truly laid down.

In theſe Obſervations the Station Lines only are inſerted, the Offsets from thence to the Bounders are omitted, the manner of plotting them being already laid down before.

When the Bounders of the Field are drawn, and the Name thereof entred in the middle of the Plott, you may with a piece of Bread rub off the Marks that were made with the Pencil round the Edge of the Protractor and meridian Line, ſo will the Plott be ready for caſting up.

But if ſeveral Fields are to be plotted together, you muſt draw a Line through the firſt Station Point in each, parallel to the Meridian in the firſt Plott, from which the Plott of each Field may be laid down in the ſame manner as *Fig.* 17.

Obſerve, neither the Circle nor Figures, expreſſing the Angle which each Line makes with the Meridian, are uſed in Practice, though inſerted in the Scheme to demonſtrate the Nature of the Work; alſo if you lay the Edge of the thin plotting Scale cloſe to the Edge of the parallel Ruler, and move it forwards on the Paper with the parallel Ruler, till the Edge of the Scale cuts the Point at *a*, and bring the beginning of the Numbers on the Scale to the Point *a*, you may draw the Line *a b* by the Edge of the Scale held in that Poſition to 500, the Length of the Line without drawing any other but the Station Line it ſelf.

SECT. III.

A New Method of calculating or caſting up the Area of a Plott of Land in Acres, &c.

ACcording to the Rules before mentioned in Chap. 1. the whole Plott muſt be reduced into Trapezias and Triangles, and the Length of each Baſe and Perpendicular meaſured by the Scale; but ſince it is often neceſſary to lay down the Plott by a ſmall one, as $\frac{1}{4}$ of an Inch or leſs; if you err 8 or 10 Links in taking off the Length of the Baſes and Perpendiculars (which may eaſily happen if the Lines be not drawn very neat and ſmall) and there being ſeveral ſuch Baſes and Perpendiculars, the Error may be conſiderable in the whole Plott, and then alſo the Baſe and Perpendicular of each of theſe Triangles muſt be multiplied together ſeverally, and their Products added together for the whole Content.

Whereas by this Method the whole Plott, (let it conſiſt of many Sides or few) is caſt up by applying the Scale but to one Baſe and one Perpendicular, and conſequently by one Multiplication, and the Truth of the Work is demonſtrated by the firſt Theorem in Chap. 1. *viz.* That Parallelograms (and conſequently Triangles) conſtituted upon the ſame Baſe, and between the ſame Parallels are equal.

Let the four-ſided Figure *a b c d*, *Fig.* 18. be reduced to a Triangle, whoſe Area ſhall be equal to that of the four-ſided Figure.

Firſt extend one of the Sides as *c d*, then lay the parallel Ruler to the Points *a* and *d*, and move it parallel till the Edge cuts the Point *b*, then by the ſame Edge make a Mark in the extended Line *c d* at *e*: Laſtly lay a ſtrait Ruler to the Points *e* and *a*, and draw the Line *e a*, ſo ſhall the Area of the Triangle *a c e*, be equal to the Area of the four-ſided Figure *a b c d*.

For the Triangles *d o e*, and *b o a*, having Baſes of the ſame Length, and lying between the ſame Parallels are evidently equal; then if the Triangle *b o a* is left out of the four-ſided Figure *a b c d*, and the Triangle *d o e*, taken in, and the Areas of theſe two Triangles being equal; it follows, that ſuch an equal Quantity of Space is left out in one part of the Figure as is taken in on the other, and the Area muſt ſtill be the ſame.

Again, let *Fig.* 19. be reduced into a Triangle.

Firſt extend the Line *f o*, and apply the parallel Ruler to the Points *o* and *b*, and move it up parallel to the Point *a*, and where the Edge cuts the extended Line *f o*, make a Mark at *g*, then lay the Ruler to the Point *g* and *c*, and move it up to *b*, and make a Mark in the extended Line or Baſe at *h*.

Lay the Ruler to the Points *h* and *d*, and move it to *c*, then make a Prick in the Baſe at *i*.

Lay the Ruler to the Points *i* and *e*, and move it to *d*, and make a Mark in the Baſe at *k*.

Laſtly draw the Line *k e*, ſo ſhall this ſeven-ſided Figure be reduced to a three-ſided one whoſe Areas are equal, ſo may the Triangle *f e k* be caſt up by one Multiplication only.

But Note, inſtead of laying the Ruler to the Points *i* and *e*, if you had laid it to *d f*, and moved it up to *e*, and drawn the Line *z d*, the Triangle *z d i*, would have contained the ſame Area as *f e k*, and this often is neceſſary to prevent the Sides of the reduced Triangle being extended too long, and making the Angles thereof too acute.

Apply the ſame Scale by which the Plott was laid down to the Baſe, and meaſure its Length, alſo meaſure the Length of the Perpendicular; multiply theſe two Sums together; the half of their Product is the Content of the Plott in ſquare Links, which reduce into Acres, *&c.* as before directed.

Alſo obſerve that we commonly chuſe to extend one of the ſhorteſt Sides of the Plott to be the Baſe of the Triangle, as the Side *f o* which we draw with a black lead Pencil as *o k*, as well as *k e*, *i d*, or *z d*, and rub em off again with a Piece of Bread, as ſoon as the Content of the

Field is entred with its Name in the middle thereoſ.

If in uſing the parallel Ruler at the firſt Tryals you find it apt to ſlip on the Paper, which you may do if you be not very careful to hold it cloſe down thereto, that Inconvenience may be prevented, if you make uſe of three ſmall Pins or Needles, thus: Stick the three Pins in the three Firſt Angles, as at *o*, *a*, and *b*, then apply one of the inner Edges of the parallel Ruler, to the firſt and third *o* and *b*, and move the other inner Edge to the Second at *a*, take out the Pin at the Second, and put it in the Baſe or Line extended where the Ruler cuts it as at *g*; again lay the Ruler to this Pin at *g*, and to another at the Fourth Angle at *c*, and move the Ruler to the Fifth Angle at *d*, take out the Pin at *d*, and ſtick it in the Baſe at *h*, and proceed in this manner with the reſt till the Plott is reduced.

SECT. IV.

Shewing how to reduce the irregular Bounders of a Field to ſtrait Lines, in order to find the Area thereof.

LET *a b c d e f g h i k*, *Fig.* 20. repreſent the Bounders of a Field, whoſe Content is deſired.

Firſt, produce ſome one of the longeſt Sides as *i k*, then lay the parallel Ruler from the Angle *i* to *g*, the next but one, and move it up to the Point *h*, and where it cuts the Line produced, make a Mark at *r*, and draw the ſtrait Line *r g*, and it will reduce that Side of the Figure bounded by the two Lines *i h*, and *h g*, to another bounded by *r g* one Line only.

In like manner *r g* being produced, and the parallel Ruler laid from *g* to *e*, and moved up to the Angle *f*, the Edge cuts the extended Line *r g*, at *y*; Secondly, lay the Ruler from *y* to *d*, and move it up to *e*, it cuts the extended Line *e g* at *z*; Thirdly, lay the Ruler from *z* to *c*, and move it up to *d*, and where it cuts the extended Line *r g*, make a Mark at *x*; Laſtly, draw the ſtrait Line *y c*, ſo ſhall the Side *g c* which conſiſted of the four Lines *g f*, *f e*, *e d*, and *d c*, be reduced to the Side *y c* conſiſting of one Line only, and in like manner might we proceed, if the Lines were never ſo many; ſo may the ten-ſided Figure be reduced to a four-ſided one, and then to a Triangle which may be caſt up by one Multiplication only.

This is the ſame Method before laid down for reducing a many ſided Figure to a Triangle, but if you have not a parallel Rule, do thus:

Having produc'd the Side *k i*, lay the Edge of a ſtrait Ruler from *i* to *g*, then take with a pair of Compaſſes the Diſtance from *h* to the Edge of the Ruler, and with this Diſtance let one Point of the Compaſſes move gently cloſe to the Ruler, while the other traces out a Line parallel to it, and croſſes *k i* at *r*, and draw *r g* as before.

In the ſame manner deal with the other Sides, uſing the Compaſſes in this manner inſtead of a parallel Ruler.

Provide a plate of thin Braſs in form of an Arch of a Circle, near whoſe ends let there be drill'd ſmall Holes, through which ſtring it with a very fine Hair; and then an Hedge as *g c*, *Fig*. 20. bends in and out in ſeveral Places, and thoſe Bends contain very ſmall Spaces; lay the Hair over it length-ways, ſo that the Quantities cut off from the Figure thereby, may be equal to thoſe added to it, and with a protracting Pin near the ends of the Hair, make two Marks, through which, draw a ſtrait Line, and ſo will this irregular Side be reduced to a regular one; and here it may be obſerv'd that in very ſmall Bends by the Eye, you may judge better than by the Compaſſes.

But if Hedges conſiſt of large Curvatures, chuſe out ſuch Points, and ſo many of them that Right-lines drawn from Point to Point may vary the Quantity by ſuch Quantities only as may be rejected, and herein the Hair will be a Ready Aſſiſtance

SECT. V.

The manner of reducing hypothenuſal to horizontal Lines.

WHEN we meet with an Hill in Surveying a Piece of Land; we can only meaſure the hypothenuſal or ſlope Lines thereof, on the Superficies of the Hill, which being conſiderably longer then the Baſe or level Lines on which the Hill is ſituated, as the Lines *a b*, *b c*, *Fig.* 21. are longer than *a o*, *o c*, therefore when we plott this Hill (becauſe we cannot make a convex Superficies upon a piece of plain Paper) we muſt reduce the hypothenuſal to horizontal, Lines that all the Lines in the Plott may be laid down alike in *Plano*.

For the Lines of level only muſt be expreſs'd in a Plott; that every Field therein may lye in its true Situation; for if *a b*, and *b c*, were laid down on Paper as meaſured in the Field, they would reach to *d*, and not only thruſt the next Hedge out of its true Poſition, but alſo take up a great Space in the next Field, making that too little.

Let *Fig.* 21. repreſent an Hill; at the foot of which the Theodolite is planted, which being ſet level in order to meaſure the Angle at *a*, the Teleſcope when directed towards *b*, at the top of the Hill, cuts the Ground; therefore take the Pin out of the Quadrant, and elevate the Teleſcope to the Mark at *b*, (which muſt be ſet the ſame Diſtance from the Ground as the Teleſcope is) and when the Hair cuts the Mark at *b*, the Index ſhews the horizontal Angle on the Limb, and the Quadrant the Angle of Elevation *b a o*, 25 Degrees 50 Minutes both at the ſame time, which note in the Field Book one over againſt the other.

The Inſtrument removed from *a*, and planted level on the top of the Hill at *b*, the Teleſcope when directed towards *c*, cuts the Element, therefore take out the Pin from the Quadrant, and depreſs the Telleſcope to the Mark at *c*, and then the Quadrant will cut 21 Degrees 34 Minutes, and the Length of *a b*, as meaſured up the Hill, by the Chain is 1200 Links, and *b c* 1416.

In order therefore to plott theſe Obſervations, firſt, draw the Right-line *a d*, but do not ſet the Length 1200 Links thereon, becauſe the Angle of Elevation is noted in the Field Book againſt the horizontal Angle, which ſhews that this Line is to be reduced to a Level; therefore lay the Center of the Protractor to *a*, the Diameter coincident with *a d*, and againſt 25 Degrees 50 Minutes, the Angle of Elevation, make a Mark, and through it draw the obſcure Line *a b*, ſetting thereon 1200 Links the Length of the Hypothenuſe, at the End of which make a Mark at *b*.

Having drawn the Angle of Elevation *b a o*, take a ſquare Protractor or any other Square that hath one Right Angle, and two ſtrait Edges and apply one Edge thereof to the Right Line *a d*, whilſt the other Edge cuts the Point *b* in the obſcure Line *a b*, and thereby let fall a Perpendicular from the Point *b*, which falls on the Line *a d* at *o*, ſo ſhall the Line *a o*, be the true horizontal Line which muſt be laid down in the Plott.

In the ſame Manner reduce the Hypothenuſe *b c*, by firſt drawing the Angle of Depreſſion *d o e*, 21° 3′4 ſetting the Length of the Hypothenuſe *b c* 14, chain 16 Links on the obſcure Line *o e*, and where that Length 1416 Links reaches from *o*, make a Mark at *e*. Laſtly, from *e* let fall a Perpendicular on the Line *o d*, which falls at *c*, ſo ſhall the Line *o c*, be the true Horizontal Line.

Or elſe having noted the Quantity of the Angle of Elevation, and Length of the Hypothenuſe in the Field Book, you may find the horizontal Line by the help of the following Table.

A Table ſhewing how many Links to deduct out of every Chain's Length in the Hypothenuſal-Line.

Deg.	*Min.*	*Lin.*	*Deg.*	*Min.*	*Lin.*	*Deg.*	*Nin.*	*Lin.*
4	3	$\frac{1}{4}$	19	57	6	29	32	13
5	44	$\frac{1}{2}$	21	34	7	30	41	14
7	1	$\frac{3}{4}$	23	4	8	31	47	15
8	6	1	24	30	9	32	52	16
11	29	2	25	50	10	33	54	17
14	4	3				34	55	18
16	16	4	27	8	11	35	54	19
18	12	5	28	21	12	36	52	20

Having the Angle of Elevation 25 Degrees 50 Minutes, and the Length of the Hypothenuſe *a b*, 12 Chains given thence to find the Length of the horizontal Line.

Look in the Table for 25 Degrees 50 Minutes, and againſt it you will find 10 Links, and ſo many muſt be deducted out of every Chain in the Length of the Hypothenuſe, then if 1 Chain or 100 Links requires 10 Links to be deducted from thence, 12 Chains or 1200 Links, requires 120 Links to be deducted; therefore ſubtract 120 Links from 1200, the Remainder is 1080, the Length of the horizontal Line *a o*.

Again, the Angle of Depreſſion at *b*, is 21 Degrees 34 Minutes, and the Length of the Hypothenuſe or ſlope Line *b c* 1416 Links, you will find in the Table againſt 21 Degrees 34 Minutes 7 Links, then if 100 : 7 : 1416 : 99, therefore ſubtract 99 Links out of 1416 the Length of the ſlope Line, the Remainder is 1317 Links, the Length of the level Line *o c*; But if you cannot find the given Angle of Elevation in the Table, make uſe of that which approaches neareſt thereto; and *Note*, Surveyors in Practice ſeldom take notice of a gradual Aſcent, if it does not make an Angle of above 5 or 6 Degrees or thereabouts, the difference between the ſlope and level Line, being then inconſiderable, except in ſome extraordinary Caſe, and then 'tis ſafeſt to make uſe of the firſt Method here laid down, becauſe the Table is too ſhort, but if you have a correct Table of Sines and Logarithms, you may make uſe thereof.

If you are working with the Chain, and would find the horizontal Line of an Hill, you may carry a ſmall Quadrant in your Pocket, with which meaſure the Angle of Altitude, and note it in the Field-Book againſt the Chord or Sextant of the horizontal Angle obſerved at that Station, (but let the Mark be ſet the ſame Diſtance from the Ground with your Eye when you obſerve the Angle of Altitude) and proceed to reduce the Line as aforeſaid.

Alſo you may obſerve an Angle of Altitude if you have only the plain Table in the Field, by turning it down into the notch of the Ball and Socket, making it ſtand Perpendicular by applying the String and Plummet thereto, and then the Index and Sights ſcrewed to the Center of the Table may indifferently ſerve the turn, but a Quadrant is better.

You muſt ſhade over that part of your Plott where the Lines are thus reduced with the Repreſentation of Hills, leſt another Perſon ſhould meaſure them by the ſame Scale with the other Lines, and find them to differ.

If a Field have the bottom and top Lines level, and both Sides riſing alike, it is to be accounted but as a declining level, and to be meaſured as a Level Ground in regard of the Quantity of Superficies, though the ſide Lines muſt be reduced to make a regular Plott in reſpect of the adjacent Fields that are level; but if a Ground be level at one End and both Sides, and an Hill riſing up along the Middle, or if there be ſeveral Hills in the Middle, thereof the Superficies will be more than in a Plain bounded by the ſame Limits.

Now Surveyors differ in their Opinion, in reſpect of caſting up the Content of ſuch a Field; ſome argue on the Tenant's Behalf, that ſince all Vegetables ſtand in a Perpendicular on the Earth; (that is, grow ſtrait upwards) as much will grow on the horizontal Line as on the Hypothenuſe, and therefore the Lines ought to be all reduced to a level, and the Content to be deduced from the Plott ſo laid down.

Others ſay that there ought to be marks placed on the top of the moſt remarkable Hills, and the Chain drawn over Hill and Dale, and the ſlope Lines laid on the Paper of the ſame Length as meaſured in the Field, and the true Content in Acres, *&c.* deduced from thence although the Slopes be reduced afterwards, that the Field may be laid in its true Situation in reſpect of others adjacent in the fair Plott.

'Tis hard to determine which way is to be practiſed in all Caſes; for though by the laſt Method you will have the true Quantity of Superficies more nearly given, yet the allowance in the firſt is often but reaſonable, if the Soil of the Hills is not ſo profitable as if the whole Field was ſituated on a Plain, but the Reader may uſe which he ſhall think moſt proper.

CHAP. IV.

Shewing how to Survey and make a perfect Draught of ſeveral pieces of Land lying together as a Mannor, &c. *Alſo how to compare the Bearing and Angles one with another, at each Station, as obſerv'd by the Theodolite, in order to correct any Error that may ariſe in meaſuring the Angles in the Field as well as protracting them on Paper.*

SECT. I.

HAVING in the former Chapters laid down the beſt and moſt practical Methods for meaſuring any Piece of Land by the moſt proper Inſtruments, I here ſubjoin the manner of Surveying ſeveral Parcels lying together; an Example of which may be taken from the ſmall Tenement or Farm, *Fig.* 22.

Firſt I take a View of the Land, conſidering at which Part thereof it will be moſt convenient to begin, and proceed with the Work; and becauſe 'tis beſt working in a Lane as often as an Opportunity preſents; therefore I ſet up the Theodolite at ⊙ 1 in *Charlton* Field.

Then I enter in the Field-Book the Title of the Survey, and in the middle Column ⊙ 1, and then ſend a Station Staff forwards in the Lane, as far as I can ſee diſtinctly, (the farther the better) as to ⊙ 2, (and when the Station Lines are within the Fields, I ſend the Staff to the next eminent Bend in the Hedge, or even to the farther end thereof, if the Line from the Inſtrument to the Staff be not at too great a Diſtance from the Hedge, ſo as to cauſe Offsets greater than a Chain or a Chain and half, or thereabouts, for Offsets taken too long are not ſo eaſily laid off at right Angles from the Station Line) and to that Staff at ⊙ 2, I direct the Teleſcope, and note the Degrees in the Box cut by the north End of the Needle, *viz.* 356 Degrees 10 Minutes, which I enter in the Field-Book for the Bearing of this firſt Station Line.

Then I ſet up a Staff in the Hole over which the Center of the Inſtrument was plac'd, to which Staff I direct one of my Aſſiſtants to apply the Ring at one End of the Chain, whilſt the other Aſſiſtant ſtretches it out in a right Line towards ⊙ 2, letting it lye on the Ground in that Direction; till the Occurrences in this Chain's Length are entred in the Field-Book, *viz.* I meaſure the Diſtances of the Chain from the Bounders of each Field, which I enter in the Columns of Offſets, that on the right Hand of the Chain in the right Hand Column, and that on the left in the left Hand Column; and if the Land is Part of that which I am about to ſurvey, I write in one of the outſide Columns by what Name it is call'd, but if it belongs to a Stranger, I write the name of the Owner thereof, and in all Caſes expreſs to which Land the Hedge belongs.

So at the Length of 20 Links from ⊙ 1, I lay the Offset Staff at right Angles with the Chain, and meaſure the Diſtance from thence to the corner of Turfy Leas, which I find to be 15 Links; therefore in the middle Column repreſenting the Station Line I write 20, and againſt it in the right Hand Column of Offsets I enter 15; likewiſe when I come to 40 Links in the Chain-Line I am againſt the Corner of Cow-paſture; therefore, I lay the Offset Staff to the Chain, and meaſure the Diſtance from thence to the Corner of Cow-paſture 80 Links, which I enter in the left Hand Column of Offsets againſt 40 in the middle Column, denoting that at the Length of 40 Links from ⊙ 1 the Offset, 80 Links reached the Corner of Cow-paſture on the left Side of the Station-Line.

The Hedges on each ſide the Lane, running on very nearly ſtrait from theſe Corners, I take no more Offsets in this firſt Chain's Length nor at the ſecond; but when I have laid the Chain a third time, and come againſt 80 Links, I there take an Offset on the left Hand of the Chain Line, becauſe the Hedge varies its Direction, making a conſiderable Bend; for though the Diſtance from the Chain to the Hedge continually varies from the Corner to this Place; yet I only take Offsets at each End, omitting the intermediate Parts; ſince when the extreams of a right Line are given, that right Line is alſo given, but when the Hedge runs on with a continued but irregular Curviture, then I take Offsets at every Chain or half Chain's Length, or oftner as the Thing requires.

In this manner I proceed with the Chain till I come to the Staff at ⊖ 2, obſerving as I go along the Bends in the Fences on each ſide of the Lane, to every one of which I take an Off-ſet, writing the Length of each on the right or left ſide of the middle Column in the Field-Book repreſenting the Station Line, according as they were laid off in the Field.

Note, the Mark ⊖ in the Field-Book denotes a Station; *B* a Bearing, ∠ an Angle, *cu.* the cutting of an Hedge by the Chain, *a g*, ſome remarkable Object on the farther ſide of the Hedge, as another Fence ſhooting up thereto; *ret.* return to a former Station, *&c.*

Being come to ⊖ 2, I there plant the Inſtrument, and ſend the Station Staff forwards in the Lane as far as I can ſee it, as to ⊖ 3, and then bring the Index to 360 on the Limb, and turning the whole Inſtrument about I direct the Teleſcope to the Staff left at ⊖ 1, and there fix the Inſtrument; and then turn about the Index on the Limb, till through the Teleſcope I ſee the Staff at ⊖ 3, and then find that the north End of the Needle points at 338 Degrees, and the Index cuts on the Limb 161 Degrees 50 Minutes; therefore under ⊖ 2, in the middle Column of the Field-Book, I enter 338 Degrees, and under that 161 Degrees 50 Minutes, denoting that at the ſecond Station the Bearing of the ſecond Length is 338 Degrees, and the Angle which the Index cuts on the Limb is 161 Degrees 50 Minutes.

The Rule I obſerve in meaſuring each Angle is this; firſt I bring the Index to 360, and with that part of the Limb towards me, I direct the Teleſcope to a Mark at the laſt Station, and there fix the Inſtrument; then I turn about the

Index on the Limb, till I ſee the Hair in the Telleſcope cut a Mark at the next Station before me, ſo ſhall the Needle ſhew the Bearing of the next Line, and the Index on the Limb ſhews the Quantity of the Angle at the preſent Station.

The Angles and Bearings of the Lines are taken at once ſetting the Index, as eaſily and expeditiouſly as the Angle it ſelf only; therefore inſert the Bearing of each Line in the Field-Book, as you ſee in the Form thereof; for then you may prove the Truth of your Work in the Field at each Station, before you leave it, by one of the following Rules.

If to the preſent Bearing, be added 180 Degrees, and from the Sum you ſubtract the laſt Bearing, then the Remainder will be the preſent Angle.

Or if to the preſent Angle, you add the laſt Bearing, and from the Sum ſubtract 180, then will the Remainder be the preſent Bearing.

But if the Degrees to be ſubtracted are more than thoſe from which they are to be ſubtracted, the latter muſt be encreaſed by 360, and then ſubtract. And if the Remainder be more than 360, then abate 360, and the Reſult gives the Degrees required.

So at ⊙ 2, if to the preſent Bearing 338 00′, you add 180°, the Sum is 518°, 00′ from which Sum, if you ſubtract the laſt Bearing at ⊙ 1, 356° 10′, the Remainder is 161° 50 equal to the preſent Angle.

Likewiſe, if to the Bearing at ⊙ 3 1° 30′, you add 180 Degrees, the Sum is 181° 30′, which is leſs than 33800′, the Bearing of the laſt Station, therefore 181° 30′ muſt be encreaſed by 360, and then the Sum is 541° 30′, from which if you ſubtract 338, the Bearing of the laſt Station, the Remainder will be 203° 30′, equal to the preſent Angle.

In like Manner may any other Angles be examined, and if found erroneous, the Error may be corrected, before 'tis communicated to the following Part of the Work.

Therefore when you have noted the Bearing of the preſent Station, write it in one of the outſide Columns of the Field-Book, and adding 180 thereto, ſubtract the Bearing at the laſt Station there-from; and then, if the Angle thus calculated from the Bearings, doth agree with that which the Index cuts on the Limb, you may conclude the Angle is rightly obſerved, and therefore may be entred in the Field-Book.

But obſerve, tho' the Numbers thus compared will be very nearly alike, yet ſometimes they may differ ſome few Minutes, becauſe the Diviſions in the Box being ſo much ſmaller than thoſe on the Limb, the Degrees and Minutes can't be eſtimated alike in both; but yet you will be ſure always to correct and avoid any groſs Error before you proceed with the following Work; and to this End the before-mentioned Rules are of excellent Uſe.

Theſe Directions I ſhall not repeat, tho' I make Uſe of them throughout the whole Work, unleſs any thing new occurs in meaſuring of the other Lines and Angles, referring the Reader rather to the Field-Book and Plan of the Work, than tiring him with Repetitions.

From ⊖ 2: I proceed with the Chain towards ⊖ 3: but at twenty Links in the firſt Length from ⊖ 2, I am againſt the Hedge that parts Home-cloſe from Turfy-Leas; therefore I take an Offset thereto perpendicular from the Chain Line, and enter in the Field-Book *a g* 17 Links, and this will hereafter be of Uſe in cloſing the Plott.

Being come to ⊖ 3, I there obſerve and prove the bearing and Angle at that Station, and then proceed with the Chain towards ⊖ 4; but firſt at

⊙ or the preſent Station, I meaſure an Offset to the right 10 Links, and to the left 20 Links; at 41 in the Chain Line; I am againſt the Orchard Hedge at 204, the Orchard Pales at 261, I am againſt the Gate that leads into the Yard, and alſo againſt another that goes into Cow-Paſture; therefore to each of theſe Remarks I meaſure an Offset from the Chain Line, and enter them in the Field-Book.

In going from ⊙ 4 to ⊙ 5, the Chain touches the Brow of the Ditch at 2 Chain 20 Links from the laſt Station; therefore againſt 220 in the Field-Book I write *o*, denoting that there was *o* or no Diſtance from the Chain to the Ditch, and by the Brow of the Ditch is meant the determined Diſtance of 5 Links from the Stem of the Hedge.

Being come to ⊙ *6*, I ſend a Staff to the farther Side of the Field called the Stockin, and if I cannot ſee the Mark through the Hedge, I cauſe the Bows to be removed or held back till I can plainly ſee the Mark, and if that can't be done I make my Station a little on this Side, or elſe beyond ſuch a thick Place till I can plainly ſee the Mark, and draw the Chain through the Hedge in a ſtrait Line, and where it cuts the Hedge I write *cut*, as here it does at 10 Links; but if the Fence is a Wall I allow for the Thickneſs thereof, and always meaſure the neareſt Diſtance between Station and Station that can poſſibly be.

Being come to ⊙ *9* in the Stockin, I cauſe a Staff to be ſet up in the very Corner of the Field next the Lane where the Bounders meet, to which I meaſure from ⊙ *9*; ſo ſhall the End of this Line coincide with the Offset which I took to this corner from the Station Line in the Lane, which will be a Proof that the Work is truly laid down when I come to protract it.

If upon a Piece of Paper with the Pen only you make an Eye-Draught of the Lane, and that Field which you have finiſhed, ſetting your Station Lines with their Numbers, as you made them in the Field, you will plainly ſee your Work as you go along, and be able to diſtinguiſh which Bounders of the preſent Field are already obſerved in the Precedent, as well as be directed, with a great deal of Eaſe, how to proceed with your Work, when you come to protract it.

Having made all the neceſſary Obſervations round the *Stockin*, I return to Θ 9, and with 360 on the Limb towards me I direct the Telleſcope to a Mark, at the laſt Station before I came to this, *viz.* Θ 8, and fixing the Inſtrument there, I next direct the Telleſcope to 10, and note the Angle and Bearing at that Station; then I lay the Chain through the Hedge from Θ 9 towards Θ 10, and take an Offset to the Fence where each Partition Line joins it on the other Side, by the Help of which, together with the other Offsets on the further Side in the Lane, moſt of the inward Fences of the Orchard, Garden *&c.* may be drawn.

From Θ 10 I cannot ſee into the very Corner next the Lane, therefore I take an Offset thereto 20 Links from the Station Line, and ſo are the out Lines of the Garden, Yard, *&c.* finiſhed.

Then I return to Θ 8 in the *Stockin*, and here it may be obſerved, that when I deſign to return to any Station, before I leave it I cut up a Turf with a little Paddle, which I fix in one End of the Offset-Staff, or make ſome ſuch Remark that I may be ſure readily to find the Place in which the Station Staff before ſtood; and in the Field-Book to this Mark Θ I write return; then planting the Inſtrument at Θ 8, I direct the Telleſcope to the Mark left at ⊖ 7, and here alſo I obſerve as a general Law, to obſerve the Angle with that Line which was meaſured immediately before I came to the Station where I took the Angle the firſt time: So here I obſerve the Angle made with ⊖ 7, ⊖ 8, and not with any other, as ⊖ 8, ⊖ 9; therefore according to this conſtant Law I direct the Telleſcope back to ⊖ 7 in the *Stockin*, and fixing the Inſtrument there, I next direct the Telleſcope to ⊖ 11, in *Home-Cloſe*, and *Note* the Angle, *&c.* as in the Field-Book.

After I have meaſured the Angle *&c.* at ⊖ 11, and am going forwards towards ⊖ 12, at 76 Links of the Chain I perceive my ſelf over againſt the Fence that parts *Out-Wood* from *Crab-tree-Cloſe*, I therefore aſk the Follower of the Chain, how many Arrows he hath in his Hand, he anſwers 4, therefore I enter in the middle Column of the Field-Book 476, and againſt that on the left I write 61, the Length of the Offset, denoting, that at the Length of 4 Chains 76 links from ⊖ 11, I laid off an Offset to the left, 61 Links, and proceed to obſerve and enter in the Field-Book the reſt of the Occurrences round *Home-Cloſe*, cloſing it at the End of the Line from ⊖ 12 next the Lane.

Then I return to ⊖ 12, and proceed to ⊖ 13, cloſing *Turfey-Leas* at the Corner; to which I took the firſt Offsett from ⊖ 1, in Charlton-Field.

In the ſame Manner I proceed round *Crabtree-Cloſe*, entring the ſeveral Occurrences as you find them in the Field-Book.

At ⊖ 17, I cauſe a Staff to be ſet up cloſe to the Fence where the Hedges join one another; to which Staff I meaſure ſtrait from ⊖ 17, cloſing *Outwood* at the Extremity of the Station-Line, which coincides with the Offsett laid off from ⊖ 7, in the *Stockin*.

Having finiſhed all the Fields on this Side the Lane, I return to ⊖ 6, obſerving this general Rule, never to make a Tour greater than Neceſſity requires, but always to cloſe each Field as ſoon as poſſible: So inſtead of going up the *Lane* from ⊖ 2, if I had turned off into *Turfy-Leas*, and cloſed firſt *Turfy-Leas*, and then *Crabtree-Cloſe*, &c. the Work had been done as well.

Being at ⊖ 6, I cauſe a Staff to be ſet up in a convenient Place, on the farther Side of *Garrot-Field*, as at ⊖ 18, laying the Chain through the Hedge, from ⊖ 6, towards ⊖ 18; and becauſe the Hedge belongs to the next Field, I write Hedge to *Will. Green*, the Owner of the adjacent Land.

After I have obſerved the Angle at ⊖ 18, I direct the Telleſcope to a Staff ſet up by the River Side, and note the Degrees which the Index cuts on the Limb, *viz.* 131° 10′; and then meaſure from ⊖ 18, to that Staff, 300 Links, taking Offſets on each Side the Line to the Brink of the River, as you ſee in the Figure thereof; and this will be found very uſeful in all Manner of Practice, where the Bounders are very irregular, that as much Work may be performed at once ſetting down the Inſtrument as poſſible.

From ⊖ 18, I proceed with the Chain to ⊖ 19, and from thence I meaſure along the Hedge-ſide that reaches from the *River* to the *Lane*; and when I come againſt the Hedge that parts *Magg-meadow* from *Cow-paſture*, I write, *a g.* 50 Links, being ſo far diſtant from the Chain-Line; and becauſe the Hedge from this Place belonged to *Garrott-Field*, I entred it ſo in the Field-Book, but now it belongs to *Cow-paſture*; therefore I write *Hedge* to *Cow-paſture*.

Then returning to ⊖ 19, I direct the Teleſcope firſt to ⊖ 18, and then to 20, and find

⊖ 19 to be in a ſtrait Line with ⊖ 18 and ⊖ 20; therefore I enter in the Field-Book 180, or Station-Line continued, proceeding to obſerve and enter down the ſeveral Occurrences at ⊖ 20, ⊖ 21, and ⊖ 22, round *Magg-meadow*, and then return to ⊖ 21.

From ⊖ 21, I go to ⊖ 23 in *Cow-paſture*, cloſing it on the Corner, near ⊖ 1 in *Charlton*-Field; and ſo is the whole finiſhed, as far as relates to the Field-work.

If there be ſeveral Pieces of Land belonging to the ſame Manor, *&c.* you are now ſurveying, that lie diſperſed in ſeveral Furlongs in Common Fields adjacent to the ſame Manor; you may from one of your Stations on the Outſide of the Plot take the Bearings to each Piece, by cauſing a Mark to be ſet up thereon, and meaſuring the Diſtance from that Station to each Mark: So may each Piece be plotted in its true Form, and laid in the ſame Situation in the Plot as on the Land it ſelf: And in your Table of References or Terrier, you may inſert the Name of the Furlong where each Piece lies, with the Name of other Perſons Land that lies round it, as a Direction to the Steward or other Perſon, to find each Piece.

Obſervations and Dimenſions of Land lying in the Pariſh of **W——**, *in the County of* **L----** *Part of the Eſtate of* ——— *31ſt of* March, 1724.

Remarks	*Offsets*	*Station Lines*	*Offsets*	*Remarks*
		Θ 1 *in Charlton-Field*		
	B	356°. 10′		
Corner of Cow Paſture, Hedge to Paſture.		20	*ag.* 15	*Corner of Turfy Leas, Hedge to Turfy Leas.*
	ag. 80	40		
	10	280		
		300	20	
	18	563		
		Θ 2 *in the Lane*		
338°. 00′	**B**	338°. 00′		
180. 00	<	161.50		
518.00	10	0		
356.10		20	*ag.* 17	*Hedge to Home-Cloſe.*
161.50		446		
		Θ 3 *in the Lane*		
	B	1°. 30′		
	>	203.30		
	20	0	10	
1°. 30″		41	*ag.* 10	*Orchard-Hedge*
180 00		204	*ag.* 15	*Orchard-Pales*
181.30 *Gate into Cow Paſture.*	35	261	20	*Gate into the Yard.*
360.00 *Hedge to Ditto.*		290	18	*Corner of Barn*
541.30	20	388	*ag.* 24	*Calves Croft-Hedge.*
338.00				
203.30		435		

Gate

Remarks	*Offsets*	*Station Line*	*Offsets*	*Remarks*
		Θ 4 *in the Lane*		
	B	349°·30′		
	>	168.00		
	ag. 20	90		
	13	140		
		220	0	*on Stockin Hedge.*
Gate into Garrot Field, Hedge to Field.	16	500		
		626		
		Θ 5 *in the Lane*		
	B	13°, 50′		
	<	204,20		
	10	0	20	
		64	12	
	35	152		
	30	236	10	
		Θ 6 *in the Lane*		
	B	93° 30′		
	<	259 40		
Corner of Stockin	0	10 *int.*		
	into Stockin			
	6	270		
	3	500		
	40	750		
		Θ 7 *in Stockin*		
	B	193°. 30′		
	<	280. 00		
Hedge to Wood	23	0		
	60	335		
	45	620		
	*ag.*20	668		
		680		

Remarks.	*Offsets*	*Station Lines*	*Offsets*	*Remarks*
		⊖ 8 *in Stockin*		
	B	229°00′		
	<	215.30		
Hedge to Stokin	10	0		
	10	268		
		⊖ 9 *in Stockin*		
	B	268°30′		
	<	219.20		
Corner.	30	22		
Hedge to Stokin				
		300	20	*Cloſe Stockin here*
Hedge to Lane, in corner next to Calves Croft.				
		⊖ 9	*ret.*	
	B	192°00′		
	>	143.00		
		20 *int.*		
		Into home Cloſe.		
		90	20	*Calves croft Hedge*
		220	20	*Garden Pales.*
		350	20	*Corner of Orchard Hedge.*
		361		
		⊖ 10 *in Home-Cloſe*		
	B	264°40′		
	<	252.40		
		205	0	*on Orchard Hedge*
		250	20	*cloſe here*
		255		
Out-lines of Orchard, Garden, &c. cloſe on Hedge next the Lane.				

Remarks.	*Offsets.*	*Station Lines.*	*Offsets.*	*Remarks.*
		Θ 8 *ret.*		
	B	105°00'		
	∠	91. 30		
		19 *int.*		
	into	*home Cloſe.*		
Hedge to Wood.	*corner* 5	24		
	37	353		
	28	465		
		Θ 11 *in Home Cloſe.*		
	B	193°30'		
	∠	268:30		
	60	130		
Hedge to home Cloſe	*ag:* 61	476		
Corner	18	727		
		Θ 12 *in Home-Cloſe.*		
	B	259°00'		
		∠246:20		
	ag: 28	65		
	48	268		
		667	*cloſe here*	

Cloſe Home Cloſe on Hedge to Lane, next Turfy-leas.

Remarks.	*Offſets.*	*Station Lines.*	*Offſets.*	*Remarks.*
		Θ 12 *ret.*		
	B	189°, 20′		
	>	176, 00		
		20 *int.*		
		into Crabtree cloſe		
		60	55	*Corner Hedge to Turfy-leaſe.*
		612	12	*Corner.*
		618 *int.*		
		into Charlton Field.		
		642		
		Θ 13 *in Charlton Field.*		
	B	262, 40		
	<	253, 20		
		10	28	
		510	20 *cloſe here.*	
		530 *reaches firſt Station.*		
Turfy-leas, Cloſes on Corner of Hedge next the Lane.				
		Θ 13 *ret.*		
	B	103°, 00		
	<	94, 00		
Touch on Hedge to Crabtree-cloſe.	°	135		
	17	310		
		Θ 14 *in Charlton-Field.*		
	B	69°, 00′		
	<	146, 00		
	3	320		
	26	545		
		618		

Remarks.	*Offſets.*	*Station Line.*	*Offſets.*	*Remarks.*
		Θ 15, *in Charlton Field.*		
	B	5°, 00		
	<	116, 00		
	15	60		
		166 *int.*		
	Into Charlton Common.			
	120	337		
Hedge to Crabtree cloſe.	16	563		
		645		
		Θ 16 *in Charlton-common.*		
	B	276°, 35′		
	<	91, 35		
		16 *int.*		
	Into Crabtree-cloſe			
		22	30	*Hedge to Wood.*
		710 *cloſe here.*		
Cloſe Crabtree Cloſe on Corner next Home-Cloſe and Wood.				
		Θ 16, *ret.*		
	B	10°, 20′		
	>	185, 20		
	22	220		
	60	386		
	69	434		
A Gate into the Wood.	50	611		
	10	930		
	32	1110		
	86	1268		
	142	1353		
		1553		

Remarks.	*Offsets.*	*Station Line.*	*Offsets.*	*Remarks.*
		Θ 17, *in Charlton Field.*		
	B	264°, 30′		
	≤	74, 10		
	128	225		
		318 *int.*		
		Into Clemenſon's Land		
	56	370		
	25	504		
	12	784		
		1240		
Outwood Cloſes on Corner of Stockin, next to Clemſon's Field.				
		Θ 6, *ret. into Lane.*		
	B	270°, 50′		
	≤	77, 00		
		28 *int.*		
		33	10	*Hedge to W. Green.*
		288	40	
		560	10	
		932	98	*corner to River.*
		Θ 18 *in Garrot Field.*		
	B	186°, 00		
	≤	95, 10		
	≥	131, 10		*Angle to a Bend in the River, from* ⊙ 18.
		26	75	
	56	175	82	
	25	248	53	
		300		
		225		○ *Touch the Rivers Brink*
		422	145	
		536	110	
		620	116	

Remarks.	Offsets.	Station Line.	Offsets.	Remarks.
		Θ 19, *in Garrott Field.*		
	B	96°, 30′		
	∠	90, 30		
		0	8	*Hedge to Garrot Field continu'd to River.*
		180	0	
		390	34	
		558	50	*ag. Hedge to Cow-paſture.*
		890	76	
		1024	50	*cloſe here.*
		Cloſe Garrot-Field on Hedge next to Lane.		
		Θ 19 *ret.*		
	B	186°, 00′		
	∠	180, 00		
		8 *int.*		
	Into	*Magg-Meadow.*		
		57	126	
		143	120	
		280	42	
		348	21	
		572	97	
		665	46	
		780	8	*A Bridge.*
		900	0	
		1004	25	
		1045		

Remarks.	*Offsets.*	*Station Lines.*	*Offsets.*	
		Θ 20, *in Magg-Meadow.*		
	B	151°, 00′		
	∠	145, 40		
		78	40	
		154	82	
		280	75	
		395	30	*Corner to River.*
		Θ 21, *in Magg-Meadow.*		
	B	54°, 30′		
	∠	83, 35		
		0	28	*Hedge to Magg Meadow.*
		100	64	
		245	78	
		380	59	
		452	27	
		Θ 22, *in Magg-Meadow.*		
	B	358°, 00′		
	∠	123, 20		
		0	28	
		147	53	
		378	28	*A Gate.*
		600	6	
		790	30	
		890	60	
		1010	137	*Cloſe here.*
		1032		

Magg-Meadow cloſes on the corner of the Hedge next Garrot-Field.

Remarks.	*Offsets.*	*Station Lines.*	*Offsets.*	*Remarks.*
		Θ 21, *ret.*		
	B	143°, 35'		
	∠	172, 35		
		22 *int.*		
Into Cow-paſture				
		90	6	
		244	60	*Corner to River*
		Θ 23, *in Cow-paſture.*		
	B	92°, 50'		
	∠	129, 05		
		205	55	*Hedge to Cow-paſt.*
		245	60	
		302	68	
		428	24	
		560	20	
		680	38	
		755	58	
		842	45	*Cloſe here.*
		936		

Cow-paſture cloſes on Corner next Charlton-Field.

SECT. II.

The manner of Protracting the Obſervations contained in the preceding Field-Book.

THE Protractor for this Purpoſe is beſt made a whole Circle, and marked on the Limb where the Numbers begin with *N.* or a *Flower-de-luce*, for then may that Part of the Protractor be kept always one Way as the Inſtrument in the Field, and therefore you will be leſs liable to miſtake, than if you uſe a Semicircle, which muſt be laid upwards or downwards, as the Degrees of the Bearing are more or leſs than 180; and the Diameter of this Protractor is laid Parallel to the Meridians, by the Help of equal Diviſions graved on the Protractor.

Being provided with a Sheet of ſtrong Cartridge-Paper, or (if that is not large enough) a Skin of Parchment; or which I reckon better (eſpecially for the fair Plott) if one Sheet of Paper be not big enough, to have ſeveral Sheets paſted on Cloth or Canvas well ſtretched and dried in a Frame before you uſe it; and this you may have of any Size, as the Largeneſs of the Work to be laid down requires.

Or a Practiſer may have Sheets of large Paper printed from a Copper-plate, with fine Meridian-Lines drawn thereon at exact Diſtances, and theſe will be very neat and true, and will ſave much Trouble in drawing Meridian-Lines by a Parallel Ruler, or otherwiſe.

If you have not a Parallel Ruler, you may draw Lines parallel to one another, by ſetting one Foot of a Pair of Compaſſes at or near the End of your given right Line, and with the other deſcribe the Arch of a Circle; do the ſame at the other End of the Line, and through the utmoſt Convex of theſe Two Arches you may draw a Line Parallel to the firſt.

Having drawn Parallel Right Lines at convenient Diſtances throughout the Paper marked with N. S. repreſenting Meridian, or North and South Lines, I pick out ſome Place in one of theſe Lines, to repreſent the firſt Station, as at ⊖ 1, Fig. 22, and lay the Center of the Protractor on the Point ⊖ 1, the Diameter being Parallel to the Meridian Line, and the Beginning of the Degrees of the Protractor towards N. or upwards; and becauſe the Bearing of the firſt Station Line is 356°, 10', I make a Mark with my Protracting Pin againſt that Number, cloſe to the Limb of the Protractor, to which Mark I draw an obſcure Line from ⊖ 1, repreſenting the Chain Line from ⊖ 1, to ⊖ 2.

Then the Field-Book being open before me, I lay the Edge of my Plotting-Scale to this obſcure Line ⊖ 1 and ⊖ 2; and becauſe I find in the Field-book that the Offsets from this Line were laid off at 20, 40, 280, 300, and 563; therefore making the Beginning of the Numbers on the Plotting-Scale to coincide with ⊖ 1, I make a Prick againſt each of theſe Numbers, cloſe to the Edge of the Plotting-Scale; and then turning the Scale perpendicular to the Line, I apply it ſucceſſively to thoſe ſeveral Points, and there prick off the Length of the ſeveral Offsets on the reſpective Sides of the obſcure Line; ſo againſt the firſt Mark in the obſcure Line, I prick off 15 Links to the Right, which gives the Corner of *Turfy-Leas*: Alſo againſt the ſecond Prick in the obſcure Line, I prick off 80 Links to the Left, which give the Corner of *Cow-paſture*; at 280, or the Third Mark in the obſcure Line, I prick off 10 to the Left; at 300, 20 to the Right;

and at the End of the Line 563 I prick off 18 Links to the Left: Laſtly, I draw Lines with Ink from Point to Point on the Outſides of this obſcure Line, thereby conſtituting the Bounders of the *Lane* ſo far.

At the firſt and ſecond Diſtances, I was againſt the Corners of *Turfey-Leas* and *Cow-paſture*; therefore, with a Black-lead Pencil I draw Two ſhort Lines, cutting the *Lane*, to denote that the *South* Fences come up to the *Lane* at thoſe Corners, and will hereafter be of Uſe in cloſing theſe Plots.

Having thus finiſhed my firſt Length, I produce the obſcure Line, if Occaſion requires, both Ways, till it is as long each Way as the Radius of the Protractor; then I place the Center of the Protractor on the Point ⊖ 2, and turn it about thereon, keeping the Beginning of the Degrees towards ⊖ 1; the laſt Station; till the Diameter coincides with the Station-Line ⊖ 1, ⊖ 2; then cloſe to the Edge of the Protractor, right againſt 161° 50′, the Degrees of the preſent Angle, I make a Mark with my Protracting-Pin; and to that Mark from ⊖ 2, draw an obſcure Line, repreſenting the Station-Line, from ⊖ 2, to ⊖ 3.

And that I may be ſure the Line ⊖ 2, ⊖ 3, is drawn in its true Poſition, I turn about the Protractor, the Center ſtill coinciding with ⊖ 2, till the Diameter be Parallel with the Meridians; the Beginning of the Numbers of the Protractor being towards N. on the Meridian Line, and then will the Line ⊖ 2, ⊖ 3, before drawn, meet the Limb of the Protractor againſt 338°, 00′, the Bearing of the Line ⊖ 2, ⊖ 3, which proves the Line ⊖ 2, ⊖ 3, to be truly laid down.

And thus may the Plott be laid down by the Angles, and examined by the Bearings.

The conſtant Rule I obſerve in drawing the Angles is this: To lay the Diameter of the Protractor on that Line which brought me to the preſent Station, where the Angle about to be laid down, was taken; and to keep the Beginning of the Numbers on the Protractor towards the laſt Station.

And in Order to prove that each Angle is truly laid down, I turn about the Center of the Protractor on the Point, repreſenting the preſent Station, till the Diameter be parallel to the Meridians, with the Beginning of the Numbers towards N. on the Meridian-Line; then will the Line laſt drawn, cut the Number, expreſſing its Bearing on the Limb of the Protractor, if that Line be drawn in its true Poſition.

In like Manner, I lay down and prove the Angles taken at the 3d, 4th, 5th, 6th, 7th, 8th and 9th Stations; and alſo the correſponding Lengths and Occurrences, continuing the Bounders to the ſeveral Offsets as I go along, drawing a ſhort Line acroſs them with a Black-lead Pencil, where the Remarks *a*, *g*, *&c.* are noted in the Field-book, breaking off the Fences where there are Gates: So at the laſt Length, from ʘ 9, when I have drawn that Line in its true Poſition, and made it of its juſt Length, as noted in the Field-book, I find its Extremity to coincide with that Point in the Fence, to which I laid off an Offset from 388 in the Station-Line ʘ 3, ʘ 4, in the *Lane*, which proves that the Angles and Lengths encloſing the *Stockin*, are truly laid down.

But if the Extremity of the laſt Line does not coincide with the Extremity of the laſt Offset laid off from the Station-Line ʘ 3, ʘ 4, both denoting the North-weſt Corner of the *Stockin*, the Lines and Angles deſigned to encloſe the ſame

Stockin, are not truly laid down, and therefore muſt be corrected before I proceed.

Next I lay the Protractor on ⊖ 9, the Diameter coincident with the Line ⊖ 8, ⊖ 9, being the ſame Line which brought me to that Station; and having laid down the Angle, ⊖ 8, ⊖ 9, ⊖ 10, I prick off the ſeveral Offſets, marking them as the Field-book directs, where the Lines of Partition within come up to the Hedge.

Having drawn the Chain-Line from ⊖ 10, and ſet off the laſt Offſet therefrom 20 Links, I find the Extremity of that Offſet to coincide with the Mark I drew croſs the Fence at the 2d Offſet from ⊖ 3, which proves the Work to be truly laid down.

The Out-Lines round the Orchard, Garden, Yard, *&c.* being drawn, the Angles within, about the Buildings, may be meaſured with a Bevel; or elſe with the Chain only, (as directed in the Uſe of the Chain) which, together with the Remarks on the Outſides, will be an eaſy Direction for drawing the ſeveral Bounders within thoſe Lines.

Having finiſhed the Ground-plot about the Buildings, I find the next Station in my Field-book, marked ⊖ 8. *ret.* therefore I return to ⊖ 8, in my Draught, and lay down that Angle by the Line immediately preceding that Station, *viz.* ⊖ 7, ⊖ 8, and proceed to ⊖ 11, laying down the ſeveral Occurrences as noted in the Field-book.

The Rules I obſerve in theſe Caſes, are, to number with Black-lead all the Stations I have already laid down in my Draught, and to expreſs thoſe Numbers ſucceſſively one after another, in a Piece of a waſte Paper.

If the Number of the preſent Station doth not immediately ſucceed that of the laſt, but is greater by an Unit than any of the Numbers in the waſte Paper, then I lay down the Angle of the preſent Station with the Line I meaſured immediately before I came to it, and number it as in the Field-Book.

But if the Number of the preſent Station is greater than any in the waſte Paper by more than an Unit, there hath been ſome Omiſſion in the waſte Paper, which muſt be rectified.

If I come to a Station whoſe Number is already entred in the waſte Paper, then I return to that Station in my Draught, and there lay down that Angle with the Line meaſured, immediately before I came to this Station the firſt Time.

Thus obſerving theſe Directions, may the Plot be laid down without any Burthen at all to the Memory; and if it was ſurveyed by one Man, it may be plotted by another, provided the Perſon who ſurveyed it did obſerve theſe Rules; and any Method of keeping a Field-book, that lays a Burthen on the Memory, is imperfect, and not fit for Practice.

The remaining Part of the Work is reſerved for the Exerciſe of the Reader: The Plan thereof was here laid down by a Scale of $\frac{1}{4}$ of an Inch: I ſometimes lay down the Plot of each Field by a Scale of half an Inch or larger, if the Plot will lie on one Sheet of Paper, and caſt up the Content of each ſeparately by that Scale; and for this Purpoſe, the Sheets with Meridians ready printed thereon, are very ſerviceable, though I afterwards lay down the whole Plan together by a Scale of a Quarter of an Inch or leſs, entring the Content of each Field, as caſt up by the large Scale in the Middle thereof.

SECT. III.

Of Reducing Plots.

THE Plot of a Manor or Lordſhip conſiſting of ſeveral Hundred Acres lying together, being laid down by a Scale of a Quarter of an Inch or leſs, may yet be larger than is deſired, and therefore muſt be reduced into a leſſer Compaſs. Now for the Performance of this Work there are ſeveral Inſtruments, as, a long Scale made with a Center-hole at One Third Part thereof; ſo that Two Third Parts may be numbred one Way with equal Parts, from the Center-hole to the End, and the other Third Part numbred the other Way with the ſame Number of equal Parts, though leſs according to what Proportion you pleaſe; but to paſs by this, and ſeveral others, I ſhall only give an Inſtance of the Parallelogram, which for Generality, Exactneſs and Diſpatch ſurpaſſeth all others, and is commonly made of Six Wooden Rulers joined together, and ſupported by Braſs Feet, with Holes in the Rulers for ſetting the Inſtrument to certain Proportions.

But I have lately ſeen one of theſe Inſtruments made of Braſs in a different Form from the other, and much better, becauſe it may be ſet to any given Proportion whatever, by the Help of Sliding Centers, that are moved along certain Lines calculated for that Purpoſe, and divided on the Sides of the Parallelogram; ſo that a Plott may be reduced with the utmoſt Exactneſs to any given Ratio, in Reſpect of the former, either in Proportion, as the Length of the Sides of the foul Plott ſhall be to the fair one, or elſe as the Area of the one to the Area of the other; and another Thing may be ſaid of this Inſtrument, that Curves are as well reduced thereby as Right-Lines; which by any other Inſtrument is exceeding difficult, if not impoſſible to be done.

The Parallellogram being fixed upon a very ſmooth and even Table, and the foul Plott, and fair Paper faſtened thereon, one over-againſt the other, ſet the Parallellogram to what Proportion you would have your reduced Plott be of, in Reſpect of the former; then bring the Point of the Tracer to one of the outmoſt Angles of the foul Plott, and put in the Point which is to draw, in its Place, letting it reſt on the fair Paper; then move the Tracer with a gentle, equal Motion, over all the Lines of the foul Plott; ſo ſhall the Motion thereof occaſion the Drawing-Point to draw upon the clean Paper or Parchment, the true and exact Figure of the former Plott, tho' of another Bigneſs, according to what Proportion you ſet your Inſtrument; which will better appear by ſeeing the Inſtrument once uſed, than Words can poſſibly explain.

When you have gone round the Lines that encloſe one Field, you may take out the Drawing-Point, and bring the Tracer to any other Point on the foul Plott; then put the Drawing-Point in its Place again, and proceed on with your Work.

Note, This Inſtrument is uſeful, not only for this Purpoſe, but alſo for Copying any ſmall Print, *&c.* in Miniature. But for Reducing great Plotts of Land, it ſhould be made of a larger Size than is commonly uſed for other Purpoſes.

SECT. IV.

Directions for Beautifying and Adorning of Plotts.

HAving reduced the Plan of the Lordſhip, Manor, *&c.* to the intended Bigneſs; 'tis neceſſary to draw imaginary Lines both vertical and horizontal, denoted by Letters at the Top and Bottom, and alſo on the Sides, to be referred to by the Table of References, for the ready finding of any Field or Parcel of Land therein contained, ſuch as you will find in the new Maps of *London*, *&c.*

The *North* Part of the Plott is always ſuppoſed to be placed upwards, and the *Eaſt* to be on the Right Hand,

The Repreſentation of Hedges ought to be laid down on the ſame Side of the Fences that they are in the Land, and to be broke off where there are to be Repreſentations of Gates.

The Out-Borders of the Plott, at leaſt ſuch as border next to the Demeſnes, ought to be fill'd with the adjacent Hedges, and the Tenants or Owners Names of the Grounds.

If you deſcribe all Rivers, Highways, Windmills, great 'lone Trees, Gates, Stiles, *&c.* that fall within your Plott, it will add to the Beauty thereof.

The Ground-Plott of Buildings, ought in all Caſes to be expreſſed by the ſame Scale that the reſt of the Plott was laid down by, and to be taken Notice of in the Table of References; but never go about to draw the Repreſentation of an Houſe or Barn in the Midſt of the Plott, ſo big as will cover an Acre or two of Land.

But if you would expreſs a Gentleman's Seat, or Manor-houſe, 'tis beſt done in ſome Corner of the Draught, or in a Plan by itſelf, annext to that of the Eſtate to which it belongs. And the Houſe muſt be drawn in Perſpective, (as you will be ſhewed hereafter) and if the Gardens, Walks and Avenues to the Houſe are expreſſed, it muſt be in the ſame Manner; and where there are Trees, they muſt be ſhadowed on the light Side.

If you will take the Pains, you may, in one of the upper Corners of the Plan, draw the Manſion-Houſe, *&c.* in the other the Lord's Coat of Arms, with Mantle, Helm, Creſt and Supporters, or in a Compartiment, blazoning the Coat in its true Colours: In one of the Corners at the Bottom, you may deſcribe a Circle, with the 32 Points of the Mariners Compaſs, according to the Situation of the Ground, with a *Flower-de-luce* at the *North* Part thereof, ever allowing the Variation of the Needle: And in the other Corner, make a Scale equal to that by which the Plott was laid down, adorning it with Compaſſes, Squares, Ovals, *&c.*

Having wrote the Name and Content of each Cloſe about the Middle thereof, you may, about the Bounds of each Field or Encloſure, with a ſmall Pencil and ſome tranſparent Colour, neatly go over the black Lines; ſo ſhall you have a tranſparent Stroke or Margin on either Side of your black Lines, which being ſhadowed, will add a great Luſtre and Beauty to the Plott.

If you would have your Fields all coloured, it will not be amiſs to pounce over the Paper or Parchment with ſome Staniſh-Grain and burnt Allom, and a double Quantity of Roſin, finely ſearced and lightly pumiced, to preſerve the Paper from being pierced through with the Colours; or wet it over with Allom-Water, which will add to the Luſtre of the Colours.

Then lay on the Colours in Manner following, being firſt ground, and bound with Gum-Water very thin and bodileſs: Arable for Corn, you may waſh with pale Straw-Colour, made of yellow Oker and White-lead; for Meadows, take Pink and Verdigreaſe in a light green; Paſture in a deep green of Pink, Azure and Smalts; Fenns, a deep green; as alſo Heaths of yellow and Indico; Trees, a ſadder green, of White-lead and Verdigreeſe; for Mudd-Walls and Ways, mix White-lead and Ruſt of Iron, or with Okers brown of *Spain*; for white Stone, take Umber and White, Water or Glaſs may be ſhewn with Indico and Azure or Black-lead; for Seas, a greeniſh Sky-Colour, of Indico, Azure, Smalts, White-lead and Verdigreeſe.

Having waſhed your Pencil very clean, take a ſmall Quantity of the Colour, and on the Inſide of the bounding Line draw the Colour along, of an equal Breadth, as near as you can, broader or narrower as the Field is in Bigneſs; and having gone round the Field in this Manner, ſwill the Pencil in fair Water, and ſtrike along the Inſide of the coloured Line, bringing it more down towards the Middle of the Field; and this will ſoften your Colour, and make it ſhew as if it loſt itſelf by Degrees to the very Colour of the Paper: Laſtly, with a Pen take ſome of that Colour which ſhadoweth the Colour you laid on the Field, and go over the Black-lead Line only; ſo ſhall your Field be finiſhed.

In this Manner, you may make 100 Fields in one Plott, of divers Colours, obſerving, as near as you can, not to colour Two Fields adjoining to one another of the ſame Colour; and therefore it will be convenient to underſtand what Colours beſt ſet off one another; and as near as you can, lay the Encloſures adjoining to one another, of Two ſuch Colours, that one Shadow may ſerve both.

This Colouring and Adorning of Plotts, is rather the Painter's Work than the Surveyor's: Yet if he has Time to ſpare, and Patience to finiſh the Work, it may prove a pretty Diverſion: But for general Practice, I would recommend the Uſe of *Indian*-Ink, which ground very fine upon a ſmooth Tile, and the Hedges or Bounders of each Field ſhadowed therewith, will look very neat, and make the Plott reſemble one done from a Copper-Plate, if rightly managed.

The Water-Colours before-mention'd, you may have in Shells ready prepared (being much readier than to trouble yourſelf with Grinding, *&c.*) as alſo the *Indian*-Ink, Pencils, *&c.* at Mr. *Keyton*'s, a Colour-Shop, in *Long-Acre*, *London*.

CHAP. V.

Shewing how to meaſure any Piece of Land, by the Chain only.

THE Content of any Piece of Land may be ſound, or a Plott thereof made, by the Chain only: So that if a Perſon is not furniſhed with Inſtruments more artificial, he may work with the Chain only in the following Manner, though it be ſomewhat laborious and tedious.

SECT. I. *Let. Fig.* 23. *be the Repreſentation of a Field, whoſe Content in Acres is deſired, without any Plott thereof.*

FIrſt, I walk about it, and ſet up Marks at the ſeveral Angles, *a*, *b*, *d*, *e*, *g*, *h*, *k*, *l*, *n*, viewing (as I go along) from which Angle to which Angle it will be moſt convenient to run a Diagonal or Baſe Line, as the Line *a*, *g*; ſo that a Perpendicular from the oppoſite Angles, as *b* and *n*, may fall upon this Diagonal or Baſe, in a convenient Manner at Right Angles: And *note*, we commonly chuſe the longeſt Line between any Two oppoſite Angles that form the Trapezia or Triangle, to be the Baſe Line.

Having a Sheet of Paper in Readineſs, on which to draw an Eye-Draught of the whole Work, I make ſome Remark near the Angle, at *a*, and lay the Chain thereto, ſtretching it in a ſtrait Line towards the oppoſite Angle *g*; then I draw a ſtrait Line on the Paper, to repreſent the Line *a*, *g*, which I am about to meaſure; and proceed with the Chain towards the Angle *g*.

When I have meaſured 4 Chain on the Line *a*, *g*, I perceive my ſelf almoſt over-againſt the Angle *b*, therefore having laid the Chain a Fifth Time, I ſet down an Arrow at the End of the Chain next *g*, and let it lie on the Ground in the Direction of *a*, *g*, and then endeavour to find a Point in the Baſe *a*, *g*; from which, a Right Line meaſured in the Angle *b*, may ſtand at Right Angles upon the Baſe *a*, *g*.

For this Purpoſe I provide a ſmall Braſs Croſs, with four plain Sights thereon, having a Socket on the Backſide, which I put on the Head of a ſhort Staff, and ſet the Staff in the Ground cloſe to the Chain; then I ſet two of the Sights in the Direction of *a*, *g*, by looking backwards and forwards through thoſe Sights till I can ſee the Mark in each Angle *a* and *g*; ſo ſhall the Mark in the Angle *b*, be ſeen through the other Two Sights, if the Staff be ſet in a Perpendicular from *b*, but if not, I move the Staff backwards and forwards by the Side of the Chain, in the Line *a*, *g*, till through Two of the Sights I ſee *a* and *g*, and through the other Two the Mark at *b*; then will the Staff be ſet in the Point *c*; and this is the exacteſt Way.

But if you have not ſuch a Croſs, get a Bit of Board made exactly ſquare, in Form of a ſquare Trencher, and from Corner to Corner draw ſtrait Lines thereon; and ſtick a Pin faſt and upright in the Line near every Corner, and make an Hole in the Middle of the Board, ſo that you may turn it on the Head of a Staff; this, for once, may ſupply the Want of the Croſs.

Having found the Point *c*, in the Line *a*, *g*, there ſet down a Staff, and take Notice how many Chains and Links it is diſtant from *a*, *viz.* 418, therefore I apply a Scale to the Right Line on my Eye-Draught, and near 418 make a Mark at *c*, but don't regard whether it be exact or no, ſo it be within 20 or 30 Links, becauſe the true Lengths of each Line are meaſured on the Ground.

Then I meaſure on the Ground, in a ſtrait Line, the neareſt Diſtance between *c* and *b* 600 Links, and erect a Perpendicular on the Point *c* on the Paper, as near as I can gueſs, by applying the End of the Scale to the Line *c*, *a*, and by the Edge thereof draw the Line *c*, *b*, ſetting cloſe thereto 600 Links, the Length of the Perpendicular; but don't regard whether the Line *c*, *b*, on the Paper, be made of its juſt Length or not, but only that the Form of the Eye-Draught may be ſomething like that of the Field, a Reſemblance thereof being all that is requiſite in this Caſe.

Next I return to the Arrow, and meaſure forwards on the Line *a*, *g*, till I am near againſt the Angle *n*; and by a few Trials, I find the Point *o*, at the Diſtance of 616 Links from *a*; and then meaſure the Perpendicular *o*, *n*, ſetting the true Length thereof 368, cloſe to its Repreſentative on the Eye-Draught.

Now I look towards the Fences *a*, *b*, and *a*, *n*, and becauſe they are ſtrait Lines, I draw *b*, *a*, *a*, *n*, on the Eye-Draught, ſo is that Side of the Field finiſhed.

From *o*, I proceed with the Chain in a ſtrait Line to *g*, and find the whole Length from *a* to

g,

g, 1375 Links; which I ſet cloſe to the Right Line on my Eye-Draught.

Then I make that Right Line on the Paper nearly the Length of 1375, and draw the Right Lines *g*, *b*, and *g*, *n*, cutting the Ends of the Perpendiculars *c*, *b*, and *o*, *n*; ſo ſhall the greateſt Part of the Field be expreſſed on the Paper, by the Trapezia, *a*, *b*, *g*, *n*.

From *g*, I meaſure in a ſtrait Line towards *d*, and when I come to *f*, I meaſure the Perpendicular *f*, *e*, 60 Links, and then meaſure out the Line *g*, *d*, to *d* 800 Links, and draw the Lines *g e*, *e d*, on the Eye-Draught, to the Extremity of the Perpendicular *f*, *e*. Now I number the Angles round the Field, if I can ſee the Marks at each, and compare 'em with thoſe on the Eye-Draught, and thereby diſcover what Part of the Field I have already meaſured, and what remains to be done.

In the ſame Manner as I meaſured the Triangle *g*, *d*, *e*, I meaſure the Triangles *g*, *b*, *k*, and *k*, *l*, *n*, and then if there be ſo many Angles expreſſed on the Eye-Draught, as there are Marks at each Angle round the Field, and if the true Length of each Baſe and Perpendicular, as meaſured in the Field, be expreſſed on the Repreſentative of the Eye-Draught, you may proceed to caſt up the Work.

The ſame Lines in the Field, *Fig.* 23, are meaſured on the Land with the Chain, as we ſhould have done on the Paper, with the Scale, if the true Plott of the ſame Field had been firſt made by the plain Table or other ſtanding Inſtrument; and therefore muſt be caſt up in the ſame Manner; for you have the true Length of each Baſe and Perpendicular given on the Eye-Draught; ſo the Sum of the Two Perpendiculars *c*, *b*, and *N*, *o*, multiplied by the Baſe *a*, *g*; alſo the Baſes and

Perpendiculars of the other three Triangles multiplied together, and added into one Sum, the half of that gives the Content of the Field, *Fig.* 23, in ſquare Links, which reduce in Acres, *&c.* as directed in Chap. I.

This is the beſt Way I can preſcribe, for finding the Content of a Field by the Chain only, without making a Plott thereof, and is only proper for plain, level Ground, and ſmall Encloſures: But even then, if the Fences are very irregular, 'tis better to go round and meaſure the Angles by the Chain, taking Offsets from the Station-Lines to the Fences.

Indeed if the Fences be tolerably regular (but there are many Fields, whoſe Sides are not ſo ſtrait as *Fig.* 23.) you may make a true Plott thereof well enough, by obſerving at how many Chains and Links the Perpendiculars meet the Baſe of the Triangles or Trapezias, by erecting Lines on thoſe Points Perpendicular to the Baſe, which made of their true Lengths, as meaſured on the Ground, the Sides of the Field may be drawn from the Extremities of the Baſe, to the End of each Perpendicular. Alſo obſerve, if any of theſe Baſes be longer than 10 Chains, leave a Staff at the Tenth, and take the Direction of the Line by that Staff, becauſe the Station will be at too great a Diſtance; and if the Length be 20, ſet up another Staff, and ſo on.

SECT.

SECT. II.

How to meaſure Angles by the Chain.

TO this End provide Three round Station-Staves, four or five Foot long a-piece; and alſo take Care that the Ring in the Middle of the Chain, and alſo thoſe at each Tenth Link be at their due Diſtance from the Chain's End.

1. In order to meaſure the Angle *d*, *o*, *e*, *Fig.* 24, ſet one of your Station-Staves as upright as you can at *o*; and putting the Ring at one End of the Chain over it, let one of your Aſſiſtants take the other End in his Hand, and ſtretch out the Chain towards *d*, whilſt you ſtanding at *o*, direct him to move ſide-ways till the Station-Staff which he has in his Hand, be brought into one Right Line with *o*, *d*, as at *a*, and there let him leave the Staff.

Then let him, with the End of the Chain in his Hand, move towards *e*; and as before, direct him to plant the Third Staff upright in the Line *o*, *e*, at *b*.

Meaſure the Diſtance *a*, *b*, in Links and Tenth Parts, if leſs than one Chain, and enter 'em in the Field-Book 88 $\frac{1}{2}$.

When you plott this Angle, take with a Pair of Compaſſes from a large Scale, the Diſtance of one Chain; and having drawn a Right-Line *d*, *o*, ſet one Foot of the Compaſſes in *o*, and with the other deſcribe an Arch *a*, *c*; then from the ſame Scale take 88 $\frac{1}{2}$ Links; and ſetting one Foot of the Compaſſes at *a*, let the other fall in the Arch *a*, *c*, and make a Mark at *b*: Laſtly, through this Mark, from *o*, draw the Line *o*, *e*, conſtituting the Angle *d*, *o*, *e*.

Obſerve to plott your Angles by a large Scale, as an Inch, or two Inches, and the Length of the Sides by a ſmaller, as a Quarter or Half an Inch: Alſo obſerve, that when the Length of the Chord *a*, *b*, is longer than one Chain, then 'tis beſt to lay out a Sextant, or two Sextants, in the following Manner.

2. The Manner of meaſuring Angles with the Chain, by laying of Sextants, is deduced from this known Property of the Circle, *viz. The Radius of every Circle is equal to the Chord of One Sixth Part* (or a Sextant) *of its Periphery.*

Let it be required to meaſure the Angle *b*, *a*, *c*, *Fig.* 25: Firſt, ſet up a Staff at *a*, and lay the Chain ſtrait in the Direction of *a*, *b*, to *i*, and at 50 Links ſet down an Arrow at *o*; then let your Aſſiſtants hold the Ends of the Chain at *o*, and *a*, whilſt you with the Middle in your Hand, laying both Halves ſtrait, ſet down an Arrow at *e*, conſtituting the equilateral Triangle *o*, *a*, *e*; ſo have you laid out the Angle *o*, *a*, *e*, a Sextant.

But if you have two Chains, you may (which is better) lay out the Sextants, ſo that each Side of the equilateral Triangle be one Chain

Now the Chain's End ſtill held at *a*, ſtretch it through the Point *e* to *d*, where alſo ſet down an Arrow: Laſtly, meaſure the Diſtance from the Arrow at *d*, to a Staff ſet up one Chain's Length from *a* at *u*; ſo ſhall the Diſtance *d*, *u*, be 76 Links, and Four Tenths of a Link; Therefore enter in the Field-Book $1^{s}. 764^{p}.$ implying 1 Sextant and 764 Parts.

In order to plott this Angle, *b*, *a*, *c*, thus meaſured, chuſe ſome Line divided into 1000 Parts, and making this Line Radius, ſet one Foot of the Compaſſes in *a*, and with the other deſcribe the Arch, *i*, *z*; and the Compaſſes continuing at the ſame Extent, ſet one Foot in *i*, and with the other, croſs the Arch at *d*, and there make a Mark.

Then take 764 Parts from the ſame Line, divided into 1000 Parts, which you made Radius; and ſet one Foot of the Compaſſes in the Mark at *d*, and let the other croſs the Arch at *u*, and there make a Mark: Laſtly, from *a*, draw a Line through the Mark at *u*, and you will conſtruct the Angle required.

If you have not a Line (which is beſt) actually divided into 1000 Parts, uſe the largeſt Diagonal Scale you have; ſo you may take off 76 Parts exactly; and the four Tenths you muſt gueſs at by moving the Compaſſes near half way in the Diagonal towards 77; alſo obſerve, the 10th of a Link is meaſured on the Land by the Offset-Staff, having a Link or two thereon, divided into Ten Parts.

2. If the Angle be more than Two Sextants, as in *Fig.* 26; then having, as before, laid off the Sextant *e*, *o*, *a*, let your Aſſiſtants hold the Ends of the Chain at *a* and *e*, while you with the Middle in your Hand, ſet down an Arrow at *x*, conſtituting another Sextant *e*, *a*, *x*.

Then the Chain being held at *a*, lay it thro' *x*, and at the other End *d*, ſet down an Arrow: Laſtly, meaſure *d*, *u*, which ſuppoſe to be 42 Links and 5 Tenths; therefore enter in the Field-Book 2^{s}, 425^{P}, ſignifying 2 Sextants and 425 Parts.

And if you would protract the Angle of *Fig.* 26, then with the Length of the Line divided into 1000 Parts, deſcribe the Arch *i*, *y*, and thereon lay *i*, *n*, and *n*, *d*, each equal to the Radius or divided Line; and afterwards lay 425 equal Parts from *d*, to *u*, and draw *a*, *u*; which gives the Angle, as required.

Obſerve, if you were about to meaſure the Angle, *Fig.* 26, and had ſet up one of your three Staves where the Station-Lines meet in the angular Point *a*, another at *i*, and the other at *u*, in the Lines *a*, *b*, and *a*, *c*; before you proceed to meaſure the Angle *i*, *a*, *u*, you muſt be ſure that the Staves at *a*, and *i*, and the Mark at *b*, are exactly in the ſame Plane; and alſo the Staves at *a*, and *u*, and the Mark at *c*, in another Plane.

So when the Staff at *a*, is planted as nearly Perpendicular as you can, move yourſelf backwards, the farther the better, 'till you ſee the Staff at *a*, and that at *i*, in one ſtrait Line with the Mark at *b*; there ſtand, and direct your Aſſiſtant to place his Staff, ſo that the Staff at *a*, exactly cover that at *i*, from the Top to the Bottom.

SECT. III.

Obſervations on Working with the Chain.

IF you would continue a ſtrait Line, you may ſignify it, by entring in the Field-Book $3^s.000$, that is, 3 Sextants.

If an Angle be external, and ſo contain more than 3 Sextants, as *b*, *a*, *e*, *Fig.* 27, put the Ring at one End of the Chain over the Staff at *a*; and taking the other End in your Hand, ſtretch out the Chain at Length towards *d*, and move Sideways, till you perceive yourſelf in a Right-Line with *a*, *b*, and there at the End of the Chain, ſet down an Arrow at *d*, ſo that *d*, *a*, *b*, are in the ſame Plane, and then ſet down the other Staff at *c*, at the End of one Chain alſo; ſo that the Staves at *a*, and *c*, be in the ſame Plane with the Mark at *e*. Now meaſure the Angle *d*, *a*, *c*, in the ſame Manner as aforeſaid, and to it add the Sextants, ſo will the Sum be the Meaſure of the external Angle *d*, *a*, *c*.

So if the Angle *d*, *a*, *c*, be 947, then will the external Angle *b*, *a*, *c*, be 3 Sextants, 947 Parts; and if the Angle *d*, *a*, *c*, be 1 s. 947, then *b*, *a*, *c*, will be 4 s. 947, *&c.*

When you protract the external Angle *b*, *a*, *e*, firſt continue the Line *b*, *a*; then from the Angle ſubtract 3 Sextants, and make the Angle *d*, *a*, *e*, equal to the Remainder.

2. But if you go on the Outſide of a Field or Wood, you may then work as though you were within the Wood, by meaſuring the Angle vertically oppoſite to thoſe that are internal: So in *Fig.* 28, if you meaſure the Angle *o*, *a*, *u*, inſtead of *b*, *a*, *e*, it will do your Buſineſs when you come to protract, as well as if you had meaſured *b*, *a*, *e*, on the Inſide; for if two Right-Lines croſs one another, the contrary or vertical Angles are equal. *Euclid.* 15. 1.

Angles meaſured by the Chain, may be laid down by a Protractor made on Purpoſe, having Sextants and Links divided thereon; and then to be uſed in the ſame Manner as other Protractors.

The Manner of keeping the Field-Book, is in all Reſpects the ſame as thoſe uſed in the 2d, or 4th Chapters, except that when the Angles are meaſured by the Theodolite, you note the Quantity of each by Degrees and Minutes: In this Caſe, when meaſured by the Chain, you note the Quantity by Sextants and Parts.

So if you were to meaſure the Field, *Fig.* 14, by the Chain, inſtead of noting 102°, 20′, for the Quantity of the Angle *b*, you muſt note 1 Sextant 734 Parts; and inſtead of 230°, 50′, for the external Angle *d*, you muſt note 3 Sextants, 886

Parts; but the Station-Lines, Offſets, *&c.* will ſtill be the ſame.

There are other Ways of Working with the Chain; but theſe before-mention'd are the beſt and exacteſt, and contain as much Variety as any one will commonly put in Practice: Alſo thereby you might meaſure an inacceſſible Diſtance, and do ſeveral other Things; but theſe are only for a Shift, when we have no other Inſtruments: And the ſame may be ſaid of meaſuring Angles.

SECT. IV.

Obſervations on meaſuring Land in Common-Fields.

WHen ploughed Lands in Common-Fields are meaſured by the Chain, 'tis uſual to meaſure the Length down the Ridge of the Land, and to take the Breadth at the Top of the Land, about the Middle, and at the Bottom; and adding theſe Three Numbers together, to take the Third Part of the Sum for the mean Breadth; but 'tis not adviſeable to take the Breadth very near the Lands Ends, becauſe the Turning of the Plough generally makes it conſiderably narrower or wider; and if in meaſuring down the Land, you find the Breadth is not nearly equal, 'tis beſt to meaſure croſs the Land oftener, as at every 3 or 4 Chains Length, and adding the ſeveral Breadths together, divide that Sum by the Number of Breadths, for the equated Breadth: And for this Practice, half the Four Pole Chain is moſt convenient, remembring either to ſet them down as whole Chains, or to make 'em ſo, when you caſt up the Content.

The ſeveral Furlongs in Common arable Fields, may be accounted as ſo many particular Encloſures, and meaſured after the ſame Manner, by ſetting up Marks at the Extremities of the Furlong, and meaſuring the Angles by the Theodolite, as before directed; and as you paſs along the Station-Lines, you may from thence take Offsets to each Man's particular Lands; and againſt that Offset write the Name of the Owner or Tenant: And when you plott that Furlong, you may, by thoſe Directions in your Field-Book (if you will take the Pains, which is not a little) expreſs each particular Land in your Draught, with its Buttings and Boundings (but the Buttings and Boundings of Land in Common-Fields is neceſſarily expreſſed in all Caſes): An Example of this is needleſs, only it may be added, that in the Survey of a large Common-Field, 'tis ſafer to divide it in Parcels, as ſeparate Fields, keeping good Marks at the Stations, than to venture the Cloſing of the Plott, by going round it all at once, and dividing it into Parcels afterwards.

CHAP. VI.

The Manner of Laying-out, or Dividing Land.

SECT. I.

PROBLEM I.

IF any Quantity of Acres be given, to be laid out in a Square Figure, annex to the Number of Acres given 5 Cyphers, which will turn the Acres into ſquare Links; then from the Number thus encreaſed, extract the Square Root, which ſhall be the Side of the propoſed Square.

So if you would cut out of a Corn-Field one ſquare Acre, add to 1 five Cyphers, and then it will be 100000, the Root of which is 3 Chains, 16 Links, and ſomething more for the ſide of that Acre.

Problem 2. If you would lay out a given Quantity of Acres in a Parallelogram, whereof one Side is given. — Firſt, turn the Acres into ſquare Links, by adding 5 Cyphers; and divide that Number thus encreaſed by the given Side, the Quotient will be the other Side, as if 100 Acres was to be laid out in a Parallelogram, one Side whereof ſhall be 20 Chains; therefore to the 100 Acres I add 5 Cyphers, which divided by 20 Chain, the

Length of the given Side, the Quotient is 50 Chains for the Length of the other Side.

Problem 3. If you would lay out a Parallelogram that ſhall be 4, 5, 6, *&c.* Times longer than it is broad. Firſt, turn the given Quantity of Acres into Links, as before, which Sum divide by the Number given, for the Proportion between the Length and Breadth, as 4, 5, 6, *&c.* the Root of the Quotient will ſhew the ſhorteſt Side of ſuch a Parallelogram: As if it was required to lay out 100 Acres in a Parallelogram that ſhall be 5 Times as long as broad; firſt, to the 100 Acres add 5 Cyphers, and it makes 10000000; which Sum divide by 5, the Quotient is 2000000, the neareſt Root of which is 14 Chains, 14 Links, and that ſhall be the ſhorteſt Side of ſuch a Parallelogram; and by multiplying that 14 Chains, 14 Links, by 5, ſhews the longeſt Side thereof to be 70 Chains, 70 Links.

Problem 4. If you would make a Triangle that ſhall contain any Number of Acres, being confined to a certain Baſe: Firſt, double the given Number of Acres, to which annex 5 Cyphers, and divide that Sum by the Baſe, the Quotient will be the Length of the Perpendicular: As if the Baſe given, be 40 Chains, upon which I am to make a Triangle that ſhall contain 100 Acres; firſt, I double the Number of Acres, and annexing 5 Cyphers thereto, I divide it by 40 Chains, the limited Baſe, ſo ſhall the Quotient be 50 Chains; for the Height of the Perpendicular, which I ſet on any Part of the Baſe, and from the Extremities thereof, draw the other Two Sides, which ſhall form the Triangle required.

So if when you are laying out a new Piece of Land of any given Content, altho' you meet in your Way with 100 Lines and Angles, yet you

may,

may, by making a Triangle to the firſt Station you began at, cut off any Quantity required.

SECT. II.

Of Dividing Lands.

EXAMPLE I.

SUppoſe it was required to divide *Fig.* 29, whoſe Content is 10 *A.* 3 *R.* 22 *P.* into 2 equal Parts, by a Line drawn parallel to *a*, *b*.

Firſt, the Acres, Roods and Poles muſt be reduced into ſquare Links, which may be done thus: If the Roods are $\left\{\begin{matrix}1\\2\\3\end{matrix}\right\}$ add $\left\{\begin{matrix}40\\80\\120\end{matrix}\right\}$ to the Poles, and to the Sum annex 4 Cyphers; divide this laſt by 16, and write the Quotient Figures, if they be 5, after the Acres. But if the Quotient Figures are but $\left\{\begin{matrix}4\\3\end{matrix}\right\}$ write $\left\{\begin{matrix}1\\2\end{matrix}\right\}$ $\begin{matrix}\text{Cypher}\\\text{Cyphers}\end{matrix}$ after the Acres, and then the Quotient Figures; ſo will you have the ſquare Links required.

Therefore 10 *A.* 3 *R.* 22 *P.* reduced into ſquare Links, will ſtand thus:

$$\left\{\begin{matrix}120\\16\ (1420000\ (88750\\\text{Square Links--}1088750\end{matrix}\right\}$$

Having reduced the Acres, *&c.* into Square Links, they make 1088750, the half of which is 544375, next draw a Line by gueſs parallel to *a*, *b*, as the Line *c*, *d*, and then caſt up the Content of the Figure *a*, *d*, *c*, *b*, which ſuppoſe 494375 Square Links leſs than 544375, by 50000 Square Links, which ſhews that the Partition-Line muſt be ſet forwarder from *b*, *a*.

Now, in order to know how much *c*, *d*, muſt be ſet forwarder, I divide the Exceſs 50000 Square Links by the Length of the Line *c*, *d*, 953 Links, and it quotes 52 Links; therefore from *c*, I ſet off 52 Links, and draw the Line *f*, *e*, parallel to *b*, *a*, and it will be ſufficiently near the Partition-Line.

This is performed by the ſecond Problem of the laſt Section; but if thoſe Parts of the Bounders *c*, *f*, *d*, *e*, be not nearly parallel, then 'tis beſt to draw a Triangle to *c*, *d*, inſtead of the Parallelogram *c*, *f*, *d*, *e*.

But if *c*, *d*, had cut off the Quantity *a*, *d*, *c*, *b*, greater than that required, then the Partition-Line had been more towards *a*, *b*, whoſe Diſtance might be found as before.

Examp. 2. Suppoſe it was required to cut off from *Fig*. 30, 6 Acres towards *g*, *f*, by a Line drawn from a given Point in the Bounder *g*, *a*, at *a*.

Firſt, reduce the given Quantity, 6 Acres, into Square Links, and they will be 600000; and then draw the Line *a*, *b*, by Gueſs, from the given Point *a*, and caſt up the Content of *g*, *a*, *b*, *f*, which amounts to 431680 Square Links, which is too little.

Next draw the Line *a*, *e*, from the Point *a*, forming the Triangle *a*, *b*, *e*, whoſe Content is 235600, which added to the Part *g*, *a*, *b*, *f*, amounts to 667280, which is more than the given Quantity 600000, by 67280 Square Links; therefore the Partition-Line paſſes between *e*, and *b*.

Now divide the Exceſs 67280, by 380, half the Length of the Perpendicular *a*, *c*, in Links, the Quotient is 77 Links, which ſet off from *e*, towards *b*, and draw *a*, *d*, which is the true Line of Partition.

Examp. 3. Suppoſe *Fig.* 31, was to be divided equally amongſt Three Tenants, in ſuch Manner that the dividing Lines may paſs through the Pond *o*, in the Middle of the Field, ſo that each Tenant may have the Benefit of the Water.

Firſt, Reduce the whole Figure into Square Links, and it will be found to contain 1477410; then each Tenant muſt have One Third Part thereof, *viz.* 492470 Square Links.

From *o*, to any Two Angles, as *a*, and *b*, draw the Lines *o a*, *o b*, forming the Triangle *a*, *o*, *b*; which being caſt up, amounts to 291984 Square Links, which is too little.

To the next Angle *f*, draw *o*, *f*, forming the Triangle *a*, *o*, *f*, which being caſt up, amounts to 231000 Square Links, which added to the Triangle *a*, *o*, *b*, gives 522984, which exceeds the Quantity required by 30514 Square Links.

Divide the Exceſs 30514, by 347, half the Length of the Perpendicular *o*, *g*, and lay the Quotient 87, from *f*, to *h*, and ſo ſhall *h*, *o*, *b*, *a*, *g*, be One Third Part of *a*, *b*, *c*, *d*, *e*, *f*.

Next draw the Line *o*, *e*, to the next Angle *e*, and caſt up the Content of *o*, *e*, *f*, amounting to 256410 Square Links; to which add the Triangle *h*, *o*, *f*, 30514 Square Links, the Sum is 286924, which is too little.

Therefore draw *o*, *d*, to the next Angle *d*, and caſt up the Content of *o*, *e*, *d*, 265500 Square Links, to which add *h*, *o*, *e*, *f*, 286924, their Sum is 552424 Square Links; which is more than the Third Part of *a*, *b*, *c*, *d*, *e*, *f*, by 59954 Square Links.

Divide the Exceſs 59954, by 295, half the Length of the Perpendicular *o*, *i*, and lay the Quotient 203 Links from *d*, to *k*, and draw *o*, *k*; ſo ſhall *Fig.* 31, be divided into 3 equal Parts, by the Lines *b*, *a*, *h*, *o*, and *h*, *f*, *e*, *k*, *o*, and *k*, *d*, *c*, *b*, *o*, *c*, *b*, *o*, as was required; and the Pond *o*, laid out to each Tenant apart.

Theſe 3 Examples expreſs all the Variety that moſt commonly comes in Practice; for either the Partition-Line is required to be Parallel to ſome other Line aſſigned; or to paſs through ſome given Point in the Fence; or to paſs thro' a Point aſſigned in the Land.

If a Piece of Common was to be divided amongſt ſeveral Tenants, in Proportion to the Rent which each pays for his Farm: The Numbers reduced to the loweſt Denomination (except you expreſs the Parts of Acres and Pounds by Decimals, which is better) the Rule is:

As the Sum total of all the Tenants Rent, is to the whole Number of Acres in the Piece of Land contained; ſo is each particular Tenant's Rent, to the Number of Acres to be laid out for his Part: This is very plain, and needs no Example.

So if a Piece of Common was to be encloſed, and divided amongſt ſeveral Tenants, according to the Number of Beaſt-Gates which each Tenant hath in the Common, it is to be performed (*mutatis mutandis*) by the ſame Rule.

There is no Need of Direction how to make the Lines on the Land in the ſame Poſition as on the Paper-Plot, by carrying the Chain in a ſtrait Line from Point to Point, on the Land it ſelf, as divided on the Paper: Only take Notice, that the larger the Scale is, by which the Plott is laid down on the Paper, the exacter will the odd Links of each Line be eſtimated by the Scale, in order to transfer thoſe Lines to the Land.

But if you are to divide a Wood, or very hilly Ground, ſo that you can't ſee the Marks from Side to Side, do thus:

Be ſure to keep good Marks at every Station, as you meaſure round it, that you may find the

Hole at each, in which the Staff ſtood; then having plotted the Wood, and divided it on the Paper-Plott, in ſuch Manner as deſired, plant the Center of the Theodolite directly over that Point in the Station-Line on the Land where the dividing Line cuts it, on the Paper-Plott, and bring the Index to 360, or ſet it in the ſame Poſition as it was at the forward Station when you meaſured that Angle, turning about the Inſtrument, till the Hair in the Telleſcope cuts the laſt Mark; ſo that the Telleſcope be ſet exactly in the Direction of the preſent Station-Line, where the Dividing-Line cuts, and there ſcrew the Inſtrument faſt; then meaſure with your Protractor on the Paper-Plott, the Angle which the Dividing-Line makes with the preſent Station-Line; and turn about the Index on the Limb to the ſame Angle; ſo ſhall the Telleſcope be ſet in the Direction of the Dividing-Line; then by looking through the Telleſcope, you may cauſe Staves to be ſet up in the ſame Direction: And thus proceed in a ſtrait Line, till you are far enough in the Wood, or quite through, if it be divided by one Line; but if by two Lines, you muſt continue them till they meet one another, as in the Paper-Plott.

The ſame Thing may be performed by the plain Table, or the Chain only; but thoſe Inſtruments are not ſo convenient to meaſure a Wood, or hilly Ground, as the Theodolite.

SECT. III.

How to reduce Cuſtomary into Statute Meaſure.

IF you would change Cuſtomary into Statute Meaſure, *& è contra*, the Rule is: As the Square of one ſort of Meaſure is to the Square of the other, ſo is the Area of the one, to the Area of the other.

In ſome Parts of *England*, they account 18, in ſome 20, 22, *&c.* Feet to a Pole or Perch, and 160 ſuch Perches to make an Acre, which is called cuſtomary Meaſure; whereas our true Meaſure of Land, by Act of Parliament, is but 160 Perches to an Acre, accounting 16 Feet and an half to the Perch.

So if a Field meaſured by a Perch of 18 Feet, accounting 160 ſuch Perches to the Acre, doth contain 100 Acres, how many Acres ſhall the ſame Field contain by the Statute Perch of 16 $\frac{1}{2}$ Feet? Say, As the Square of 18 Feet, (*viz.*) 324, is to 100 Acres, ſo is the Square of 16 $\frac{1}{2}$, Feet, (*viz.* 272, 25,) to 119 $\frac{9}{10}$ of an Acre Statute.

CHAP. VII.

General Obſervations touching the Surveying and Plotting of Roads, Rivers, &c. *With ſhort Hints how to make the Draught of a County, or ground Plott of a City,* &c.

IN this Seventh Chapter I have added general Directions for Meaſuring of Roads, *&c.* omitting particular Forms of Charts, as *fac ſimiles*, which would take up more Room than can be ſpared in this ſmall Tract; and indeed if the ſeveral Varieties that occur in theſe large and ſpacious Works were inſerted, it would ſwell to a large Volume: But ſince the Surveyor's Judgment in contriving and carrying on his Work muſt be his beſt Guide; theſe few Obſervations may ſerve as Memorandums of the moſt neceſſary Things in Practice, which, together with other Rules before laid down in this Tract, may perhaps be a ſufficient Inſtruction for the Performance of any Thing of this Nature.

SECT.

SECT. I.

General Directions for making a Draught of the Roads lying through any County, &c.

INſtruments fitteſt for this Purpoſe are 1. the Theodolite as before deſcribed: The Angles which each Station-line on the Road makes with the Meridian, being obſerved by the Limb in the ſame Manner, as before deſcribed in Chap. III. and the Bearings of the ſeveral Remarks from thence by the Needle. 2. The Wheel or Way-wiſer to meaſure the Length of the Lines, by driving the Wheel on the Road before you, ſo ſhall the Hands on the upper Part of the Inſtrument ſhew how many Miles, Furlongs, and Poles you go at one Time from any Station. 3. The Protractor as before deſcribed: A neat diagonal Scale of Braſs and a good Pair of Compaſſes, or rather a Pair of beam Compaſſes, with ſuch a Scale on the Beam as ſhall be agreeable to the Largeneſs of your Plott; for thereby you may lay down the Length of your Lines much exacter than by any other Way, by ſetting one Foot of the Compaſſes at one End of the Line, and moving the Socket on the Beam to one of the equal Diviſions near the other End of the Line you are about to lay down, repreſenting Chains or Furlongs; and then you may bring the Point of the Compaſs which ſtands perpendicular on the Paper to the Parts of that equal Diviſion, repreſenting Links or Poles by the Help of a ſmall Screw, there being Diviſions on the Edge of the Socket ſliding cloſe on the Beam according to *Nonus*'s Projection; ſo that the Links of a Chain or Poles of a Furlong are eſtimated in the ſame Manner as the Minutes of a Degree on the Limb of the Theodolite; for in theſe large Plans where the Diſtances of Places are determined by the Interſection of Right-lines from your Stations; thoſe ſtationary Diſtances ought to be laid down as accurately as may be, for where a Mile is laid down in the Compaſs of an Inch, a Point is conſiderable.

In order therefore to make a Draught of the principal Roads that lye through any County, *&c.* firſt begin at ſome noted Market Town, or rather at the County Town, placing the Theodolite at ſome remarkable Church, *&c.* then having a Field-book with large Margins to enter the Remarks, and the middle Column repreſenting the Station-Lines divided into three Parts, at the Head of each of which write *M.* for Miles, *F.* for Furlongs, and *P.* for Poles.

When you begin your Journey at the Top of the Field-book write the Name of the Place where you begin your Work, and making ʘ 1. in the Field-book to repreſent the firſt Station: Send ſome Perſon forwards on the Road, with a white Flag in his Hand, as far as you can ſee; and then by ſome known Sign cauſe him to ſtand; then bring the Index to 360, on the Limb, and turn the Inſtrument into the Direction of the Meridian, and there fix it; then direct the Telleſcope to the Perſon on the Road, and note the Degrees cut on the Limb for the bearing of the firſt Station-Line.

Put the Hands to the Beginnings of the Numbers on the Plate, and bring the Wheel to the Station, then cauſe one to drive it from the Place where your Inſtrument ſtood towards the Man on the Road, 'till you ſee ſome remarkable Object on either Side thereof; there let him ſtop and direct the Telleſcope to that Object, and note the Degrees which the Needle points to in the Box, and at what Diſtance the Inſtrument is planted from the laſt Station, together with the Name of the Object to which the Telleſcope was directed.

Having entered this in the Field-book, go on with the Wheel till you ſee ſomething elſe remarkable on either Side of the Road; there ſtop and take a Bearing there; and in this Manner proceed till you come up to the Man at the ſecond Station, obſerving as you go along on the Road from Station to Station: Firſt, what by Lanes, or Roads you meet with in your Way, whether they be to the right Hand or to the left, and to what Places they go, and how they incline, whether forwards or backwards, or whether they be at right Angles with the Road you are meaſuring, and note it down in the Field-book with two Lines thus = on the right or left Side of the Station-line; that is, if the Road or Lane be on the right Hand, then place it on the right Hand; but if the Road be on the left Hand, then place it on the left: If the Road doth incline forwards, then make it on either Side of the Lane or Road thus ⊭ : If the Road or Lane incline backwards, then mark it thus ⫥: If it be at right Angles with the Road you meaſure, then mark it down thus ⫤ : If another Road croſſes that you are upon, note it thus ǂ : Likewiſe ſet down at what Diſtance from your Stations the Lanes or Roads do turn out from the Road you meaſure, *viz.* at ſo many Furlongs, *&c.* a Road to the Right or Left to ſuch a Place.

Likewiſe, when you paſs over any Bridge, note it in the Field-Book, with the Diſtance from the laſt Station; as alſo the Name of the Water that runs under it, and from whence it hath its Riſe, and where it doth empty it ſelf:

So muſt you do when you paſs over any Ford or Rill.

Note down alſo, when you aſcend an Hill, and when you come to the Top thereof, and when you deſcend the ſame, and come to the Bottom thereof.

When you paſs through any Town or Village, note at how many Miles, Furlongs, and Poles you enter the ſame; and at how many Miles, *&c.* you leave it, and whether the Houſes be cloſe, or ſcattering, or on the Right or Left Side of the Road, or on both Sides thereof; alſo write down the right Name thereof; and if a Market-Town, take Notice on what Day the Fairs or Market is kept; and by what Officers the Town is governed.

Note down alſo the Mills that are on the Road, whether Water-mills, or Wind-mills, and the Diſtance from your laſt Station. If there be any 'lone Churches on the Road, note them down by their Names, and whether they be Towers or Spires, with their Diſtance from your laſt Station.

In your meaſuring along the Road, if you ſee any Churches, Manſion-Houſes, Beacons, Wind-mills, Towns, Villages, or any other Thing remarkable, you muſt take a Bearing to each, noting down in your Field-Book, the Name of the Place, and how it does bear, and at what Diſtance from your laſt Station you took this Bearing.

Then in your meaſuring forwards, at as great a Diſtance as you can, take another Bearing to thoſe Places you took laſt, provided you may but ſee them, and note the Name of the Places, and how they bear, and at what Diſtance from your laſt Station, as before.

Obſerving theſe Directions, proceed with your Work on the Road as far as you can go the firſt

Day, entring the ſeveral Obſervations in as plain and fair a Manner as poſſible in the Field-Book, and then it may be convenient to protract that Day's Obſervations, before you go any further.

Therefore, on the Paper or Parchment, on which you draw the foul Draught, let there be ruled Meridian-Lines all over, exactly parallel to one another; and chuſing a proper Place in one of the Lines, to repreſent the firſt Station, draw an occult Line from thence, making ſuch an Angle with the Meridian, as you obſerved the firſt Station-Line to do, when you directed the Teleſcope to the Man ſtanding in the Middle of the Road.

When you have drawn the Station-Line in its true Poſition, ſet thereon the ſeveral Diſtances from the laſt Station very exactly, at which you made any Remarks, as you find 'em noted in the Field-Book; and make a ſmall Prick at each, in the Station-Line: Then having made the Station-Line of its juſt Length, proceed to lay down the ſeveral Objects you obſerved on each Side the Road, in their true Situation; as ſuppoſe a Steeple that ſtands at a Diſtance from the Road, *viz.* a Mile or two; lay the Center of your Protractor on the Place at which you took the Bearing, thus, (at ſo many Poles, *&c.* Diſtance from ſuch a Station, ſuch a Steeple did bear from you 207°, 40′,) therefore, againſt the Degrees of Bearing make a Mark, and draw a Line at Length.

Then at the ſecond Place in the Station-Line, where you obſerved this ſame Steeple to bear from you, lay the Center of your Protractor, and againſt the Degrees of Bearing make a Mark, and likewiſe draw a Line at Length; and where this laſt Line of Bearing doth interſect the firſt

Line of Bearing, there place the Steeple, with the Body of the Church to the Eaſt Side thereof.

All Wind-mills, eminent Houſes, or other Remarks that are diſtant from the Road, you muſt protract in the ſame Manner as you did the Church, by the Bearings, and likewiſe write down the Name of each; and if you protract a Village that ſtands at a Diſtance from the Road, you muſt ſignify by Writing the ſame, that it is a Village; but that you may know Market-Towns from Villages, write the Name of the Market-Town in a different kind of Letter; and if you protract a Village that is in the Road, with Houſes ſcattering, you muſt place your Houſes ſcattering on the Right or Left Hand the Road, as you noted them in the Field-Book.

You muſt protract the Road all along with two Lines parallel one to the other. If your Road have Hedges on both Sides, then draw your Lines black; but if your Road be open Way, then draw it with prick'd Lines; alſo you may inſert the Quality of the Ground, whether it be a Common, Moor, or arable Land.

If the Road paſs through a Wood, then make little Trees on both Sides the Road, to ſignify the ſame ſo far as the Wood goes.

If the Road paſſes over an Hill, you muſt at the Beginning where the Hill doth aſcend, ſhadow very deep, and as the Hill doth more and more aſcend, you muſt ſhadow it lighter, till you come to the Top thereof: But if the Hill makes an Angle of above 5 or 6 Degrees, or thereabouts, and the Height be above a Furlong, you muſt find the horizontal Line of that Hill, and protract that, otherwiſe a great Error may enſue.

If there be a Village or Town on the Side of the Hill, you muſt ſhadow it likewiſe, ſo that the Houſes may be ſeen. If the Remarks that are at a Diſtance from the Road ſtand on an Hill, make an Hill to repreſent the ſame.

If your Road paſs by or through a Park, Foreſt or Chaſe, write down on your Road protracted, where you did enter the ſame, and where you did leave it, writing the Name thereof among the Trees.

If your Road paſs over a Ford, draw the River quite croſs the Road, to ſignify there is no Bridge, and write the Name of the Ford; but if there be a Bridge, then draw the River on both Sides the Road, 'till it touch the Parallel Lines; and write the Name both of the Bridge and of the River; likewiſe write on that Side of the Road that the Stream runs from you, and at what Place the River doth empty it ſelf; and on the other Side of the Road write from whence the Water or River hath its Riſe, if you can learn that of the Inhabitants.

All Rills you may ſignify, by drawing a Line croſs the Road; and Brooks may be ſignify'd by drawing Two Lines croſs the Road, and Rivers by more Lines, together with the Names; for all Rivers have Names, but Rills and Brooks have none.

It will likewiſe be neceſſary, that you take Notice of the Quality of the Way, whether it be ſtony or clayey or boggy, and write it down on the Road that you have protracted: And by this Means you will have your Road mighty full of Remarks, and it will ſhew very delightful.

SECT. II.

Containing general Directions for making the Plott of a River or Brook, by the before-mention'd Inſtruments.

FIrſt, when you come to the Mouth of the River, cauſe a Man to go and ſtand at the next Bend thereof; then plant your Theodolite at the Mouth of the River, letting your Needle hang directly over the Meridian-Line in the Box; there fix the Inſtrument faſt, and direct your Telleſcope to the Man that ſtands at the next Bending of the River, and note down the Angle in your Field-Book, as you did in the Road.

Then cauſe the Man that drives the Wheel, to meaſure between your firſt Station, and the Man at the next Bending; and note that down alſo in your Field-Book, under Miles, Furlongs and Poles.

Then bring your Inſtrument to the Man at the firſt Bending of the River, and cauſe that Man to go forwards till he finds another Bending, there let him ſtand; and placing your Inſtrument where the Man laſt ſtood, let your Needle (as before) hang directly over the Meridian-Line, and there make your Inſtrument faſt; and direct the Telleſcope to the Man that ſtands at the next Bending of the River, and note down the Angle in your Field-Book, as you did in the former: And thus muſt you proceed all along the River, to the Head thereof.

In order to take the Breadth of the River, it will be convenient to ſend ſome Body on Purpoſe croſs the River, in a Boat, (unleſs a Bridge or Ferry be near,) and let him ſet up a Staff by the Brink of the River, on the further Side, to which Staff take a Bearing, from the Place of your Standing, which call the firſt Station; alſo let another Staff be ſet up on the ſame Side where you ſtand, and call that the ſecond Station, to which take a Bearing alſo. Now meaſure in as ſtrait a Line as poſſible, the neareſt Diſtance between the 1ſt and 2d Stations, and that Diſtance note in the Field-Book with the Bearings.

Plant the Theodolite at the ſecond Station, and take a Bearing to the ſame Mark on the further Side of the River, and note that Bearing alſo in the Field-Book.

When you protract theſe Obſervations, lay the Center of the Protractor to Θ 1, and turn it about till the Diameter be parallel to the Meridians on the Paper, then againſt the Degrees of Bearing from Θ 1, to the Mark on the further Side of the River; and alſo to Θ 2, cloſe to the Limb of the Protractor make 2 Marks, through which, from Θ 1, draw 2 Lines at Length.

Set off the Diſtance between the 2 Stations on the 2d Line, and mark it Θ 2, to which Mark lay the Protractor as before, and againſt the Degrees of Bearing obſerved at this 2d Θ; to the Mark on the further Side of the River make a Mark, through which draw a Line at Length; then will this Line interſect the firſt Line drawn at your firſt Station, ſo ſhall the Point of Interſection ſhew the Breadth of the River.

In the ſame Manner, are the Diſtance of the Churches, *&c.* from your Stations on the Road, determined; and in chuſing the Diſtance of theſe Stations, 'tis very neceſſary to obſerve the Rule laid down at the Concluſion of Chap. I.

If there be a Ferry over the River, you muſt draw the River to its true Breadth, and make a prick'd Line croſs the River, to repreſent the

Paſſage of the Ferry-Boat; and note on the Side of the River the Name of the Ferry.

In meaſuring on by the River, obſerve what Bridges you paſs by, and at what Diſtance from your laſt Station; alſo whether they be of Wood or Stone, and by what Name they are called; alſo take Notice of all Corn-Mills, Paper-Mills, *&c.* and note them in the Field-Book, in the Column of Remarks, with their Diſtance from the Mouth of the River, and your laſt Station.

Likewiſe take Notice of all the Sluices (if there be never ſo many) that are on the River, and of all the Locks and Flood-gates as you paſs along, with their Names, if they have any; alſo if there be any cut Rivers from the River that you are meaſuring, note where it goes out of the River, and where it comes in again, and for what End it was ſo cut: Alſo where any Brook or River enters into that you are meaſuring, note down the Place, and the Name of the River that comes in; and alſo take an Account of thoſe Places of the River that are fordable, and note them down in your Field-Book: And in all theſe Caſes, expreſs the Diſtance of each Remark from your laſt Station, as alſo their Diſtance from the Mouth of the River.

You muſt alſo note in your Field-Book all the Towns this River doth run through, or by, with the Towns Names, and the Diſtance from your laſt Station and the Mouth of the River.

You muſt alſo take an Account of all the Churches that are on each Side the River within your View, by taking a Bearing to them at two ſeveral Places, as you did on the Road; and note them down in your Field-Book, with the Diſtance of the Place from your laſt Station, where you took the Bearing, to the Steeple both Times; by this Means you will come to know how far each Church is diſtant from the River: The ſame you muſt do by all the Wind-mills, great Houſes, *&c.* noting their Names, and Places of Situation, in the Column of Remarks in the Field-Book.

When you have thus meaſured your main River, begin to meaſure the ſeveral Branches thereof; for there are but few Rivers but have ſmaller Rivers running into them, and all thoſe ſmall Rivers ought to be done with the like Exactneſs with the great ones.

Note, All Rivers that are navigable, every Bending of them muſt be taken exactly; but for other ſmall Creeks there is no great Need; for you will find ſuch ſmall Brooks to have a Bend at every two or three Poles, nay ſometimes leſs, therefore they are to be taken thus:

Take your Sights as far as you can conveniently, till you find the Brook to have a conſiderable Bending; and if your Scale will permit, you may take Offſets to repreſent the ſmall Turnings and Windings thereof, as in *Fig.* 22: But in meaſuring a ſmall Brook, if your Scale is to be a Mile or two in an Inch, then theſe ſmall Turnings and Windings can't be deſcribed in the Map.

The Manner of protracting theſe Obſervations, is the ſame with the Roads, except the Offſets from the Station-Line to the Brink of the River, and its Breadth, which are particularly to be regarded.

S E C T. III.

General Directions for making a Map of a County, &c.

FIrſt, from the County-Town, or other Market-Town, where you began your Work, lay down the principal Roads throughout the County, protracting them truly, as you obſerved them in your Survey, inſerting the Towns, Villages, great Houſes, Croſs-Ways, *&c.* according to their true Situation, taken at Two Stations, as you went on the Road; ſo will you (if Care be taken) have the true horizontal Diſtance of all thoſe Places within Sight of the Roads, from the Road itſelf, or from one another.

Secondly, Lay down the chief River that runs through the County, ſo will you have the Situation of ſeveral more Towns, and other Remarks, as obſerved in your Survey of that River; and when the main Rivers are done, all the Branches muſt be protracted with the like Exactneſs; for the main Rivers and Branches being exactly done, will be a great Ornament to a County Map.

Thirdly, If the County borders upon the Sea, firſt protract the Sea-Coaſt exactly, and then take a Survey of and plott all Rocks, Sands, or other Obſtacles that lie at the Entrance of any River, Harbour, Bay or Road upon the Coaſt of that County, by going out in a Boat to ſuch Sands or Rocks that make the Entrance difficult; and at every conſiderable Bend of the Sands, take with a Sea-Compaſs, the Bearing thereof, to Two known Marks upon the Shore: And having ſo gone round all the Sands and Rocks, you may, upon the Plott before taken of the Coaſt, draw

Lines, which ſhall interſect each other at every conſiderable Point of the Sands; whereby you may give good Directions either for the laying of Buoys, or making Marks upon the Shore, for the Direction of Shipping; and the beſt Time to do this, is at low Water, in Spring Tides.

Fourthly, Having truly protracted the principal Roads, Rivers, *&c.* with the ſeveral Remarks obſerved from thence, you'll find moſt of the remarkable Places in the County laid down: But in Order to compleat the Work, look upon ſome old Map of the County, and contrive 3 or 4 Market-Towns, or other Towns, to meaſure through, that you have not yet laid down, and from thence to other Towns or Villages; and ſo do, till you have meaſured moſt or all the Roads that lead from Market-Town to Market-Town, taking all the Remarks you can, as you go along; and if you find any thing remarkable in the old Map, that you have not yet taken Notice of, you may go and ſurvey it. And thus, by Degrees, you may ſo finiſh a County, that you need not ſo much as leave out one Gentleman's Houſe; for ſcarce will any thing remarkable eſcape coming into your View, either from the Roads, Rivers, or Sea-Coaſt.

Fifthly, When you are in a Town, you may place your Inſtrument, if you can, upon the Steeple, and from thence take the horizontal Angles to others, by having the horizontal Diſtance of thoſe 2, from which you take your Angles given; but obſerve, all Churches are to be laid down according to their horizontal Diſtance one from the other: Therefore, if the Road between them be over Hills of a conſiderable Height, the Hypothenuſal Lines on the Road muſt be reduced to Horizontal.

Sixthly, All Parks and Foreſts muſt be truly laid down in the Map, as to their true Bounds and Situation; and all remarkable Lakes of Water: You are likewiſe to deſcribe the Quality of the County, whether it be hilly or woody, placing the Hills and Woods in their true Places.

Laſtly, Take the true Latitude of the Place, in Three or Four Places of the County; which put down on the Edge of your Map accordingly.

SECT. IV.

General Directions for taking the Ground-plott of a City or other Town.

THE Performance of this Work is very laborious, and you muſt be careful to keep the Field-book in a plain and regular Manner, otherwiſe the Multitude of Obſervations and Offſets will be apt to breed Confuſion; but if Care be taken therein you'l find the Work not very hard to be done: One that underſtands the fourth Chapter will make no Difficulty of this Section, for the ſeveral Streets, Lanes, *&c.* in a City are ſurvey'd and protracted in the ſame Manner as the Lane *Fig.* 22. The ſeveral Offsets to the Houſes, Churches, *&c.* all along the Sides of the Street being taken from the main Station-line, running through the middle thereof, in ſuch Sort as the Offsets are taken from the Station-line to the Hedges, Gates, *&c.* on the Sides of the Lane.

The Inſtruments for this Purpoſe are, 1. the Theodolite as before deſcribed, to meaſure the ſeveral Angles made by your Station-lines, as they incline out of one Street into another, and in this Caſe work with the Limb only, but never truſt to the Needle, for (beſides the Danger of its being attracted) you will find it neceſſary to lay down every Line by ſome other, given in Poſition in the Plott it ſelf, rather than by the Bearings from the Meridian.

2. The Chain; and becauſe the Ground-plott of the Houſes, Pavements, *&c.* are generally laid out by Foot Meaſure; therefore let every Link thereof be a Foot long, and Fifty of theſe Links will make the Chain of a ſufficient Length, diſtinguiſhed at every Ten Links, by Marks, as *Gunter*'s Chain is: But if the Content of any Part of the Plott be deſired in Acres, you may reduce the Feet in any Line, to Links; and for this Purpoſe the Table in Chap. I. will be a ready Aſſiſtant.

3. The Offsett-Staff, divided alſo into Feet, 5 of which may make it of a convenient Length, becauſe you will have Occaſion to meaſure many Paſſages, Alleys, *&c.* that are not wider; alſo at one End of the Staff, you may have a Piece of about 3 Foot joined, like the Squares of a Drawing-Board; and this will be a Direction to meaſure the Offsets from the Chain, at Right-Angles.

4. The Scale, (or rather a Pair of Beam-Compaſſes) according to the Bigneſs of the Plott, the Protractor, the Drawing-Pen, *&c.*

Firſt, in one of the principal Sheets, as at ⊖ 1, in the Lane, *Fig.* 22, ſet up a Station-Staff, and ſend another forwards in the Street as far as you can ſee. Then lay the Chain on the Ground exactly in the ſame Direction with the Two Stations, and with the Offset-Staff both to the right and left at Right-Angles from the Chain; meaſure the Offsets as in the Lane; taking Notice at how many Links from the laſt Station each is laid off; and when any of thoſe Offsets reach any remarkable Houſe, *&c.* or the Corner of a Street, Alley, or Court, enter ſuch a Remark againſt the reſpective Offset, in one of the Outſide Columns of the Field-Book: And in this Manner proceed to the ſecond Station.

Set up the Theodolite at the ſecond Station, and bring the Index to 360, on the Limb, turning the whole Inſtrument about till you ſee thro' the Telleſcope the Staff at Θ 1; there fix the Inſtrument, and then turn about the Index, directing the Telleſcope to another Staff ſent forwards in the Street, to the further End thereof, if you can ſee ſo far; and note in the Field-Book the Angle which the Index cuts on the Limb, with the utmoſt Exactneſs: Then proceed with the Chain towards the next Station, as before.

Having in this Manner gone through ſeveral of the principal, high Streets, that lead through one Part of the Town, it will be convenient, as you paſs along, as often as you come againſt any croſs Street, to take a Sight down it; and note the Place or Mark to which the Telleſcope is directed; and alſo at how many Links Diſtance from the laſt Station the Inſtrument is planted, when you thus look into a croſs Street; and note both theſe Places in your Field-Book, or Eye-Draught, with this Mark Θ; ſo that you may be ſure to find the Place exactly, when you begin to take your croſs Sheets.

It will be convenient, not only to enter your Obſervations in the Field-Book, but alſo to form a Sketch or Eye-Draught of the Work, as you go along, making Lines to imitate the ſame; and draw the croſs Streets, Alleys, *&c.* thereon, in ſuch Manner (as near as you can gueſs) as you ſee thoſe croſs Streets to bear from the Place of your Standing in the high Streets; and write the Name of each Street between the Lines repreſenting the ſame; and this will be uſeful when you come to protract.

Note, Before you begin your Work, it will be neceſſary to walk about the Town, and chuſe 4 or 5 principal Streets that lead out of one into another, encloſing between them ſeveral By-Lanes, Alleys, *&c.* And contrive your firſt Station in ſuch Manner, that when you come round theſe 4 or 5 Streets, the laſt Station-Line may cloſe exactly on the firſt Station-Point; and obſerve, that the fewer Angles you make in going round theſe Streets before you cloſe, the better.

This is no more than Surveying a Field; the main Difficulty will be to find your Stations, when you come to ſurvey the croſs Streets, By-Lanes, Thoroughfares, *&c.* between the eminent Streets that you firſt went round; but you may help your ſelf herein, if you lay one End of the Chain at ſome Door, or other remarkable Place on the Right Side of the Street, and draw it in a ſtrait Line through the Station-Point, to ſome other Remark on the other Side of the Street, taking Notice at how many Links from the Right, the Chain cut the Station: You may alſo much help yourſelf herein by your Eye-Draught.

When the Station-Line leads you into a Square, you may plant the Theodolite in the Middle thereof, and from that one Station direct the Teleſcope to the Corners, (very often there are but four, and the Sides all ſtrait) and meaſure the Diſtances from that Station to the Corners, as in Chap I. Sect. 3. But if you would take Notice of particular Houſes therein, or if the Sides are very irregular, then go round it; but Lanes and Alleys are laid down by Offsets only, from the Station-Line through the Middle.

Having thus finiſhed one Part of the Town or City, you may proceed to another, till the whole be finiſhed; but this is a Work that will take up a great deal of Time.

The Manner of Protracting this Work, is the ſame as in the preceding Chapters, therefore particular Directions are needleſs; but 'tis beſt to protract ſo much as you ſurvey in one Day, before you proceed with more; and for this Purpoſe, a Skin of fine, ſoft Parchment is better than Paper, unleſs the Paper be very fine, and paſted on Cloth or Canvas. The Ground-Plotts of Churches, muſt be very exactly taken, and laid down in the ſame Manner on the Draught, and ſhadowed very deep; the ſame of Houſes.

Alſo if you uſe a Protractor that will lay down Minutes, as deſcribed in Chap. II. your Work will be more likely to cloſe; for you cannot be too curious in obſerving and laying down the Angles, eſpecially thoſe in the principal Streets.

FINIS.

APPENDIX
TO THE
Practical SURVEYOR.

CHAP. I.

Of LEVELLING.

SECT. I.

THE Inſtrument moſt approved for this Purpoſe, (a Figure whereof you have in the Beginning of this Book) conſiſts, 1. Of a Braſs Telleſcope of a convenient Length (the longer the Exacter, provided the Parts of the Inſtrument that ſupport it, be made proportionably ſtrong:) Within this Telleſcope is fixed an horizontal Hair, and a ſmall Micrometer, whereby Diſtances may be determined at one Station near enough for the Buſineſs of Levelling: Upon this Telleſcope is fixed, with two ſmall Screws, the Spirit Tube, and Bubble therein, which Bubble reſt exactly in the Middle of the Tube, when the Telleſcope is ſet truly level.

2. Under the Telleſcope, is a double Spring, with 2 Screws, by which the Bubble is brought exactly to a Mark in the Middle of the Tube; to which Spring is fixed a Conical Ferril, which is a Direction for the Telleſcope to move horizontally at Pleaſure. There is alſo a three-legged Staff, a Ball Socket, and 4 Screws, to adjuſt the

horizontal Motion the ſame with that belonging to the Theodolite, before deſcribed.

Provide 2 Station-Staves, each 10 Foot long, that may ſlide one by the Side of the other to 5 Foot, for eaſier Carriage; let them be divided into 1000 equal Parts, and numbred at every 10th Diviſion, 10, 20, 30, 40, &c. to 100, and from 100, 110, 120, &c. to 200, and ſo on till you come to 1000; but every Centeſſimal Diviſion, as 100, 200, 300, to 1000, ought to be expreſſed in large Figures, that the Diviſions may be more eaſily counted; and you may have another Piece 5 Foot long, divided alſo into 500 Parts, to be added to the former, when there ſhall be Occaſion.

Upon theſe Staves are Two Vanes, made to ſlide up and down, which will alſo ſtand againſt any Diviſion on the Staff, by the Help of Springs. Theſe Vanes are beſt, made 30 Parts wide, and 90 Parts long; let the Faces of them be divided into 3 equal Spaces, by 2 Lines drawn lengthways; let the 2 extreme Spaces be painted white, and let the middle Space be divided alſo into 3 ſmaller equal Spaces, and let that in the Middle be painted white, the other 2 black, which will render them fit for all Diſtances.

Being thus provided with a good Inſtrument, Two Station-Staves, a Chain, and Two Aſſiſtants, you may proceed to your Work; but firſt it will be neceſſary to make a Trial whether or no your Inſtrument be well adjuſted.

SECT. II.

How to adjuſt the Inſtrument.

CHuſe ſome Field or Meadow, that is nearly level, and ſet down the Inſtrument about the Middle thereof, and make an Hole in the Ground, under the Center of the Inſtrument;

from which, meaſure out in a Right-Line, ſome convenient Length, as 20 Chains, and there leave one of your Aſſiſtants with his Station-Staff; then return to the Inſtrument, and meaſure out the ſame Number of Chains, *viz.* 20, the other Way, by the Direction of the Inſtrument, and laſt Station-Staff, as near in a Right-Line as you can gueſs, and there leave your other Aſſiſtant with his Station-Staff; ſo will the Inſtrument and Two Station-Staves be in the ſame Line.

Then return to the Inſtrument, and ſet it horizontal, which is preſently done by the Ball and Socket, and turn the Telleſcope about on its horizontal Motion, to your firſt Aſſiſtant, and move the Telleſcope by the Two Screws in the double Spring, till the Bubble reſts exactly in the Middle of the Spirit Tube; then obſerve where the Hair in the Telleſcope cuts the Staff, and direct your Aſſiſtant to move the Vane up or down, till the Hair cuts the Middle thereof, ſo that you may ſee as much of the Vane above the Hair as below it, and there give him a Sign to fix it; then direct the Telleſcope towards your ſecond Aſſiſtant, and proceed in the ſame Manner; ſo are the Vanes on each Staff equidiſtant from the Center of the Earth.

Remove the Inſtrument to that Aſſiſtant which is neareſt the Sun, if it ſhines, that you may have the Advantage of its Rays upon the other Aſſiſtant's Vane, and there ſet down the Inſtrument as near the Staff as you can; then having ſet the Inſtrument horizontal, ſo that the Bubble reſts in the Middle of the Tube; obſerve what Diviſion on the Staff is then cut by the Hair in the Telleſcope, above or below the Middle of the Vane, for ſo many Diviſions muſt the other Aſſiſtant's Vane be raiſed or depreſſed, which direct him to do accordingly.

But becauſe the Inſtrument is 40 Chains diſtant from the Station-Staff, you muſt make an Allowance for the Earth's Curvature, which by the following Table you will find to be $16\frac{6}{10}$ Parts, therefore let the Vane on the Staff be raiſed $16\frac{6}{10}$ Parts.

A TABLE *of the* Earth's Curvature, *calculated to the Thouſandth Part of a Foot, at the End of every Chain, from* 1 *Chain to* 40.

Chains	*Dec.Foot*	*Chains*	*Dec.Foot*	*Chains*	*D.Foot.*	*Chains*	*D.Foot.*
1	000	11	013	21	046	31	099
2	00	12	015	22	050	32	106
3	001	13	017	23	055	33	113
4	002	14	020	24	060	34	120
5	003	15	023	25	065	35	127
6	004	16	026	26	070	36	134
7	005	17	030	27	075	37	141
8	007	18	033	28	081	38	149
9	008	19	037	29	087	39	157
10	010	20	041	30	093	40	166

Now direct the Telleſcope to the Vane thus raiſed, and if the Hair cuts the Middle thereof, while the Bubble reſts in the Middle of the Tube, the Inſtrument is right; but if not, you muſt raiſe or depreſs the Telleſcope by the Screws in the double Spring, till the Hair cuts the Middle of the Vane, and then by the Help of the Screws that fix'd the Tube to the Telleſcope, move the Bubble till it reſts in the Middle of the Tube: So is the Level adjuſted.

SECT.

SECT. III.

Rules to be obſerved in Levelling, in Order to find the different Height of any two Places; being uſeful for conveying Water, cutting Sluices, making Soughs, &c.

SUppoſe it was required to know whether Water may be conveyed in Pipes or Trenches, from a Spring Head to any determined Place.

1. At the Head of the Spring ſet up one of your Station-Staves as nearly perpendicular as you can, and leave with one (whom you may call your firſt Aſſiſtant) proper Directions for Raiſing or Depreſſing the Vane on his Staff, according to certain Signs which you (ſtanding at your Inſtrument) ſhall give him: Alſo let him be provided with Pen, Ink and Paper, to note down very carefully the Diviſion on the Staff which the Vane ſhall cut, when you make a Sign that it ſtands in its right Poſition.

2. Carry your Inſtrument towards the determined Place you are going to, as far as you can ſee, ſo that through the Telleſcope you may but ſee any Part of the Staff left behind, when the Inſtrument is ſet horizontal; and from that Place ſend your ſecond Aſſiſtant forwards with his Station-Staff with the ſame Inſtructions as you gave your firſt Aſſiſtant.

3. Set the Inſtrument horizontal, by the Help of the Ball, and Socket and 4 Screws; and direct the Telleſcope to your firſt Aſſiſtant's Staff, and then by the Help of the Spring-ſcrews bring the Bubble exactly to the Middle of the Tube, and when it reſts there, give a Sign for your

Aſſiſtant to note the Parts of the Staff where the Vane reſts.

4. Turn about the Telleſcope to your ſecond Aſſiſtant's Staff, and by the Spring-ſcrews, as before, ſet the Bubble exact: Then direct your ſecond Aſſiſtant to move the Vane higher or lower till you ſee the Hair in the Telleſcope cut the Middle of the Vane, (but in long Diſtances the Hair will almoſt cover the Vane; however, let it be ſet in ſuch Manner that as much may be above the Hair as below it, as near as you can gueſs,) and then give him a Sign to note the Diviſion on the Staff; and always let your Aſſiſtants note the Diviſion cut by the upper Edge of the Vane.

5. Let your firſt Aſſiſtant bring his Station-Staff from the Spring Head, and give it to the ſecond Aſſiſtant, and let your ſecond Aſſiſtant carry it forwards towards the determined Place you are going to, and at a convenient Place erect it perpendicular, whilſt your firſt Aſſiſtant tarries at the Staff where your ſecond Aſſiſtant ſtood before.

6. Place your Inſtrument between your Two Aſſiſtants, ſomewhere about the Middle if you can, and firſt direct the Telleſcope to your firſt Aſſiſtant's Staff, and when the Telleſcope is levelled to one of the Diviſions on the Staff, let him note that Diviſion in an orderly Manner under the firſt Obſervation; and let your ſecond Aſſiſtant do the ſame: And in this Manner proceed over Hill and Dale, as ſtrait forwards as the Way will permit, to the appointed Place, (by only repeating theſe Directions, tho' it be 20 Miles diſtant from the Spring Head; but in your whole Paſſage let this conſtant Law be obſerved, otherwiſe great Errors will enſue, (*viz.*) That your firſt Aſſiſtant muſt at every Station ſtand between

the Spring-head and your Inſtrument; and your ſecond Aſſiſtant muſt always ſtand between the Inſtrument and the appointed Place to which the Water is to be convey'd.

Being come to the appointe[illegible] Place, let both your Aſſiſtants give in their Notes, which ought to ſtand in Manner and Form following.

First Aſſiſtant's Notes.		*Second Aſſiſtant's Notes*	
Stations.	*Parts.*	*Stations.*	*Parts.*
Θ 1	1019	Θ 1	330
Θ 2	512	Θ 2	540
Θ 3	737	Θ 3	1337
Θ 4	40	Θ 4	742
Θ 5	1495	Θ 5	30
Θ 6	1475	Θ 6	32
Θ 7	1430	Θ 7	30
Θ 8	1149	Θ 8	227
Sum.	7857	*Sum.*	3268

Theſe Notes were collected from Obſervations made with ſuch an Inſtrument, as before deſcribed, at ſeveral Stations between the Ground at the North-gate of *Hanover-Square*, and the Surface of the ſquare Pond by the *New-River Head*, near *Iſlington*. The firſt Aſſiſtant's Notes, when added together, amount to 7857; the ſecond Aſſiſtant's 3268, the Difference 45, 89 Parts; that is almoſt 46 Foot; and ſo much is the Pond higher than the Ground of that Part of the Square where the firſt Station-ſtaff was planted.

The following Obſervations were repeated in the Afternoon of the ſame Day, at quite different Stations; from the Pond before-mention'd, to the ſaid North-gate of *Hanover-Square*; and then the two Aſſiſtants Notes ſtood in the following Manner.

Firſt Aſſiſtant's Notes		*Second Aſſiſtant's Notes*	
Stations.	*Parts.*	*Stations.*	*Parts.*
⊖ 1	290	⊖ 1	1278
⊖ 2	36	⊖ 2	1515
⊖ 3	77	⊖ 3	1395
⊖ 4	68	⊖ 4	1500
⊖ 5	58	⊖ 5	74
⊖ 6	1243	⊖ 6	38
⊖ 7	998	⊖ 7	468
⊖ 8	437	⊖ 8	774
⊖ 9	306	⊖ 9	1066
Sum.	3513	*Sum.*	8108

Theſe Notes as obſerved in the Afternoon, being added together, and the leſſer ſubtracted out of the greater, the Difference is 45,95 Parts, which very nearly agrees with the former Obſervations; being but $\frac{6}{100}$ of a Foot Difference, which is inconſiderable.

Note, If from the firſt Aſſiſtant's Staff you meaſure any Number of Chains towards the Place you are going to, ſuppoſe 10, and there ſet down the Inſtrument, and then meaſure 10 Chains forwarder and there place the other Station-ſtaff, you will have no Occaſion to make any Allowance for the Curvature of the Earth, becauſe the Inſtrument being planted in the Middle of the Diſtance between the Station-ſtaves, the Errors mutually deſtroy each other.

But this meaſuring of the Diſtances with the Chain, or otherwiſe, is very tedious, and indeed impracticable in many Caſes, unleſs you make a Multitude of Stations: So if the Way between the two determined Places, whoſe different

rent Height you would know, lies over Hills and Dales, as *Fig.* 32. you muſt in that Caſe make four or five Stations (otherwiſe you will not be able to ſee any Part of the Staff, when the Inſtrument is ſet horizontal,) which might as well be done at one, (as in the foregoing Obſervations,) in the following Manner.

SECT. IV.

How to make Allowance for the Curvature of the Earth, when the Station-ſtaves are planted at unequal Diſtances from the Inſtrument.

SUppoſe the Inſtrument was planted on the Eminence between the two Valleys *a*, and *b*, and the firſt Aſſiſtant with his Station-ſtaff, ſtanding at *c*, and the ſecond at *d*, and it is required to know the different Height of the Hills *c*, and *d*.

Firſt ſet the Inſtrument horizontal; and then direct the Telleſcope to the firſt Aſſiſtant's Staff at *c*, and by the Spring-ſcrews ſet the Bubble exact, obſerving where the Hair cuts the Staff, and by Signs cauſe him to move the Vane higher or lower till the Hair cuts the Middle thereof; and then give him a Sign to note the Diviſion cut by the upper Edge of the Vane, which ſuppoſe 104 Parts from the Ground, and by the Micrometer in the Telleſcope, I find the Diſtance from the Inſtrument to the Staff at *c*, to be about 10 Chains.

Then I direct the Telleſcope to *d*, and procede in the ſame Manner as before, and find that the Hair cuts 849 Parts from the Ground; and by the Micrometer the Diſtance to *d*, is determined to be about 35 Chains.

Next I look into the Table of Curvature and find againſt 10 Chain, 1 Part to be deducted for the Curvature of the Earth at that Diſtance; ſo will the firſt Aſſiſtant's Note be made 103 Parts.

Alſo againſt 35 Chains I find $12\frac{7}{10}$, which deducted out of 849, there remains $836\frac{3}{10}$ Parts which muſt be noted by the ſecond Aſſiſtant.

Now if 103, as noted by the firſt Aſſiſtant, be ſubtracted from $836\frac{3}{10}$, as noted by the ſecond, the Remainder will be $733\frac{3}{10}$; and ſo much the Hill *c*, is higher than the Hill *d:* But if you have not the Table of Curvature at Hand, then you may find the Allowance that is to be made at any Diſtance, by this Rule.

Multiply the Square of the Diſtance in Chains by 31, and divide the Product by 300000.

In this Manner making Allowance for the Curvature of the Earth, you may ſend a Station-ſtaff forwards half a Mile, or farther from the Inſtrument; and take a Sight over ſeveral Valleys at once, the horizontal Diſtance in this Caſe being only regardable.

Note, When Water is to be brought to any appointed Place; there muſt be an Allowance of $4\frac{1}{2}$ Inches for every Mile, more than the ſtrait Level, for the Current of the Water; but if the Spring-head be much higher than the appointed Place, ſo that the Water will have too violent a Current, the Pipes may be laid one up and another down; and inſtead of being laid in a ſtrait Line, the Water be brought in a crooked or winding Way.

CHAP.

CHAP. II.

Shewing the Uſe of the Theodolite, *in Drawing Buildings*, &c. *in Perſpective.*

SECT. I.

WHEN a Building is to be drawn upon a Perſpective Plane (or Picture,) the Repreſentation of the ſeveral Objects ought to be delineated thereon according to their Dimenſions and different Situations, in ſuch Manner that the ſaid Repreſentations may produce the ſame Effects on our Eyes as the Objects whereof they are the Pictures.

But without Mathematical Rules this Repreſentation cannot well be found; for when Objects are drawn by only Viewing or Looking at them, their true Repreſentations will often be miſs'd; whereas by the following Method they may always be obtained.

For all Objects appear ſuch as the viſual Angle under which they are ſeen; which Angle is taken at the Eye, where the Lines meet that do compriſe the Object; that is to ſay, an Object ſeen in a great Angle, will appear great; and another ſeen in a little Angle, will appear little; which is the principal Thing to be obſerved in Perſpective.

So the Windows *6*, 7, 8, *Fig.* 33, muſt be drawn on the Perſpective Plane of different Dimenſions (altho' on the Building one of 'em is really as big as the other) according to the Angle which the Rays from their Extremities make with the Eye at *z*.

Objects of equal Bigneſs appear greater or leſs, according to their Diſtance from the Beholder's Eye; ſo the Windows *6* and 8, are really one as big as another on the Geometrical Plane; but the Window *6*, at the End of the Building being nearer the Eye at *z*, than the Window 8 on the Front, it muſt be made ſo much larger on the Perſpective Plane, as the Window *6* is to that marked with 8.

Therefore, if the Angles, under which Objects appear, be given, thoſe Objects may be drawn on the Perſpective Plane (or Paper) according to their Dimenſions and different Situations, in the ſame Form as they appear to the Beholder at any Diſtance.

The Figures on the Geometrical Plane (or Building) are compos'd either of ſtrait Lines, or Curves: Now to find the Repreſentation of a ſtrait Line, its Extremes need only be ſought: And to find the Appearance of a Curve, we need only to find the Place of ſeveral Points therein. And hence it follows, that the whole Buſineſs of Perſpective conſiſts in finding only the Place of a Point.

But theſe Points can't be determined, unleſs by the Interſection of Right Lines. And the Reaſon of theſe Sections is, That one Line can determine nothing: Therefore it is neceſſary, that there be Two of them, which divide themſelves, (forming an Angle) for to have the Place of a Point, as will be ſeen in the following Example.

For having noted the Obſervations made by the Theodolite, the Plan of any Building may be drawn in Perſpective, without meaſuring ſo much as one Line; or coming nearer the Building than where the Inſtrument is planted.

SECT. II.

Let Fig. 33. repreſent the Building as viewed from Z, being the Place from which the Proſpect is deſired to be taken.

THE Inſtrument being planted at *z*, and the Staves made to ſtand firm on the Ground, I ſet the Inſtrument exactly level; and with the Index at 360, and the Quadrant at 0 Degrees, direct the Telleſcope to ſome Part of the Building, as to *o*, by turning about the whole Inſtrument, and there ſcrew it faſt, that it ſtir not out of this Poſition, till the ſeveral Obſervations be finiſhed.

The Inſtrument being ſet level, the Index, when turned round on the Limb, carries the Telleſcope in a Line Parallel to the Horizon, as *x*, *y*: And the Quadrant elevated or depreſſed, moves always in a Circle vertical thereto, as *w*, *z*.

Now take the Pin out of the Quadrant, and with one Hand move the Index on the Limb, and with the other elevate or depreſs the Telleſcope as there ſhall be Occaſion, till you ſee the croſs Hairs therein cut any Point on the Building; and then note down on a Piece of Paper, the Degrees and Minutes which the Index cuts on the Limb in one Column, and call thoſe the horizontal Angles: Likewiſe note the Degrees and Minutes cut by the Quadrant in another Column, and call thoſe the vertical Angles.

So the Telleſcope being directed to the Point *a*, the Index then cuts 7°, 25′, and the Quadrant 19°, 30′; and thoſe Obſervations when protracted, will give the Point *a*.

Likewiſe I make Obſervation of the Point *b*; and then depreſs the Telleſcope to the Bottom of the Building at *c*, and the Index then cuts the ſame Angle on the Limb as at *b*, and the Quadrant 8°, 30′: But this Angle of Depreſſion muſt be marked with ∧, or ſome ſuch Mark to diſtinguiſh it from the Angles of Elevation, that in Protracting that Point, it may be known to be under the Horizon, or the Line *x*, *y*.

When the Inſtrument is planted at a conſiderable Diſtance from the Building, the Ground there may be higher or lower than any Part of the Building: And then all the Points will be above or under the Horizon; and in ſuch Caſe there will be no Occaſion for this Diſtinction.

In the ſame Manner I make Obſervation of ſo many Points on the Right Side of the Houſe as is convenient; but when the Telleſcope is directed to the Point *m*, on the Left Side, the Index cuts 340°, 40′.

Now this Number 340°, 40′, muſt not be noted for the horizontal Angle, but its Complement to 360 (*viz.*) 19°, 20′, by ſubtracting 340°, 40′, out of 360; but if the Degrees be numbred by ſmall Figures from 360, the contrary Way, as 10, 20, 30, *&c.* to 60, or further, as may conveniently be done, the Numbers will encreaſe from 360, both to the Right and Left; and then the Index will always cut the Number denoting the horizontal Angle, in the ſame Manner as the Quadrant.

Having obſerved the Point *m*, the Index remaining at the ſame Angle on the Limb, I depreſs the Telleſcope to the Points 4, 3, 2, 1, and note the Degrees, *&c.* cut by the Quadrant; which when protracted, will give the Breadth of the Facies and their Diſtance one from another.

Next I obſerve the Points of the Window *e*, *i*, *u*, in the Left Wing of the Building; and becauſe theſe Remarks are on the Left Side of the Building, therefore I note them by ſuch Names as I call the ſeveral Points I look at, (inſtead of the Letters, *a*, *b*, *&c.* on the Left Side of the Column of Obſervations, (*viz.*) contrary to that Part of the Limb where the Index cuts, (which remember;) for when the Index is turned from 360, on the Limb towards the Right Hand, the Telleſcope moves towards the Left: And theſe Remarks thus noted, muſt be protracted on the Left Side of the Vertical Line *w*, *z*, *Fig.* 33.

In making theſe Obſervations, 1. Set the Inſtrument level in that Place from which the Proſpect is deſired to be made; and with the Index at 360, direct the Telleſcope to ſome remarkable Place about the Middle of the Building, and there fix the Inſtrument.

2. The Remarks on the Right Side of the Building, enter in the Column of Obſervations on the right Hand; *& è contra.*

3. If there be Angles both of Elevation and Depreſſion, mark the Angles of Depreſſion with Λ.

The Obſervations of moſt of the Points, that need to be taken of *Fig.* 33, in order to protract or draw the ſame in Perſpective, are inſerted in the following Table: And obſerve, that if the Building be regular, there will need but few Points to be given; for, where you have the Height and Breadth of one Window given, with its Diſtance from the next, the whole Row may thereby be drawn, being all of the ſame Dimenſions; but

Objects more irregular muſt be drawn by obſerving ſo many Points therein, as ſhall be neceſſary: But Practice in this Caſe is the beſt Guide.

SECT. III.

The Manner of Protracting theſe Obſervations in Order to find the Points of the Building. Fig. 33.

	Horizon. Angles	*Vertical Angles*		
	7° : 25'	19° : 30'	*a*	
	11 : 30	16 : 30	*b*	
	11 : 30	8 : 30	*c*	∧
	19 : 20	26 : 50	*d*	
	19 : 20	13 : 30	*e*	∧
	38 : 00	26 : 50	*f*	
	38 : 00	13 : 30	*g*	∧
4	19 : 20	26 : 50		
		25 : 30		
3	——	18 : 40		
2	——	9 : 35		
∧ : 1	——	1 : 00		
i	18 : 30	19 : 00		
e	18 : 30	22 : 40		
u	16 : 50	17 : 50		

FIRST draw a right Line *x*, *y*, *Fig.* 33. for the Horizontal-line; and at right Angles therewith draw another Line *w*, *z*, which repreſents the Vertical-line.

Set off the Points of Diſtance from *o*, (*viz.*) from that Point where *x*, *y*, and *w*, *z*, interſect one another: And according to what Bigneſs you would have the Plan of the Building be, make the Diſtance bigger or leſs. If you would have the Draught large, make the Diſtance large: *Et è contra.* Therefore ſet one Foot of the Compaſs at *o*, and with the ſame Extent mark the Points of Diſtance *x*, *y*, *z*.

The Horizontal-angles muſt be drawn from the Point *z*, to the horizontal Line *x*, *y*; and the vertical Angles from the Points *x*, or *y*, (according as the Remarks are noted on the right or left Side of the Columns) to the Vertical-line *w*, *z*.

The Index being at 360, and the Quadrant at *o*, when the Croſs-hairs in the Telleſcope cut the Point *o*, on the Building: Therefore the Point *o*, ſhall be the firſt Point of Sight on the Proſpective-plan.

By the Table of Obſervations I find that the Index cuts 7°. 25′. on the Limb; and the Quadrant 19° 30′, when the Telleſcope was directed to the Point *a*: Therefore lay the Center of the Protractor to z: And becauſe the Letter *a* is noted on the right Side of the Columns, lay the Limb on the Right Side of the Line *w*, *z*, the Diameter coincident therewith; and againſt 7°, 25′, make a Mark cloſe by the Limb of the Protractor.

Lay the Edge of a ſtrait Ruler to the Point of Diſtance *z*, and to that Point 7°, 25′; and where the Edge cuts the Horizontal Line, make a Mark.

Lay the Center of the Protractor to the Point of Diſtance *y*, (becauſe *a* is noted on the Right Side of the Columns) the Diameter coincident with the Line *x*, *y*; and againſt 19°, 30′, on the Limb, make a Mark.

Lay a ſtrait Ruler to that Mark, and the Point of Diſtance *y*; and where the Edge cuts the Vertical Line *w*, *z*, make a Mark at *r*.

Laſtly, Lay a Parallel Ruler to the Horizontal Line *x*, *y*, and move it Parallel thereto, till the

Edge cuts the Point *r*, in the Vertical Line; and with the Compaſs Point draw the obſcure Line *r* 5.

Then lay the Parallel Ruler to the Vertical-Line *w*, *z*, and move it Parallel thereto till the Edge cuts the Point *t*, in the horizontal Line *x*, *y*, and by the ſame Edge draw an obſcure Line *t* 9; ſo ſhall the Interſection of theſe Two Parallels determine the Place of the Point *a*, which was ſought.

In the ſame Manner may the Point *b*, or any other Point be ſound: And then theſe Points joined with Right Lines, ſhall repreſent the Lines on the Building, and bear an exact Proportion thereto, according to the Rules of Perſpective.

The Point *c* is found in the ſame Manner as *a*, only becauſe the horizontal Angle is the ſame with the Point *b*, you have no more to do but continue a ſtrait Line from *b*, through the Point *x*, in the Horizontal Line, Parallel to *w*, *z*; and then lay the Center of the Protractor to *y*, with the Limb downwards; becauſe *c* is marked with ∧ (*i. e.*) under the Horizon; and draw the Vertical Angle 8°, 30′, to ♉ in the Vertical Line; ſo ſhall a Line drawn Parallel to *x*, *y*, from the Point ♉, cut the obſcure Line *b*, *c*, at *c*, the Point ſought.

The Points *h*, *k*, *l*, *m*, *n*, *p*, *q*, on the Left Side of the Building, *Fig.* 33, have the ſame Angles with *a*, *b*, *c*, *d*, *e*, *f*, *g*, on the Right, and therefore protracted in the ſame Manner; except this Difference, that becauſe the Points *h*, *k*, *l*, *&c.* are on the Left Side of the Building, therefore the ſame Points muſt be found on the Left Side of the Vertical Line *w*, *z*, and the Protractor laid to the Point of Diſtance *x*; but the Horizontal Angles are all laid off from the ſame Point of Diſtance *z*.

Obſerve, That in Protracting theſe Points, 'tis convenient, that the Numbers on the Semicircular Protractor ſhould be made to encreaſe from the Diameter both Ways, that the Numbers may be counted thereon, both to the Right and Left: And then in Protracting any Point on a Building, 1. Draw the Horizontal Angle from the Point of Diſtance *z*, to the Horizontal Line *x*, *y*, as to *t*. 2. Draw the Vertical Angle to the Vertical Line *w*, *z*, as to *r*. 3. Draw Lines Parallel to *w*, *z*, and *x*, *y*, through the Points *t* and *r*; ſo ſhall the Interſection of the Two Parallels give the Point ſought.

But theſe Points are found with much greater Expedition, if the Paper on which you draw the Plan of the Building, be faſtened to a Drawing-Board, and the Angles laid down by the Sector in the following Manner:

For Example: Suppoſe the Point *a*, *Fig.* 33, was ſought.

Firſt, Draw Two Lines by the Side of the Tee, croſſing one another at Right Angles, as *x*, *y*, and *w*, *z*, *Fig.* 33.

Take between the Points of the Compaſſes the Diſtance *z*, *o*, and let the Sector be opened to the ſame Extent, by ſetting one Foot of the Compaſſes at the End of the Tangent-Line, at 45, on one Side of the Sector, and let the other fall at the other End of the Tangent-Line, at 45, on the other Side of the Sector.

The Sector remaining at this Extent, ſet one Foot of the Compaſſes in the Tangent-Line on one Side of the Sector at 7°, 25′, the Horizontal Angle, as in the Table; and let the other fall at 7°, 25′, on the other Side; this Diſtance ſet from the Point of Sight *o*, in the Horizontal-Line *x*, *y*, to *t*.

In the ſame Manner take off from the Sector the vertical Angle 19° 30′ which ſet on the vertical Line *w*, *z*, from *o* to *r*.

Laſtly, lay the Tee on the Drawing-board, paralleil to *w*, *z*, ſo that the Edge cut through the Point *t*, and draw the Obſcure-Line *t*, 9.

Lay the Tee to the other Side of the Drawing-board parallel to *x*, *y*: And the Edge cutting through the Point *r*. Draw the Obſcure-Line *r*, 5, ſo ſhall the Interſection of theſe two Lines *t*, 9, and *r*, 5, give the Point *a* which was ſought.

In the ſame Manner may any other Point be found in as little Time as it could be obſerved by the Theodolite; but if you have not a Drawing-board nor Parallel-ruler, you may put the Paper on the plain Table and by the Edge of the Index laid on the equal Diviſions, draw the Parallels; but a Drawing-board is better.

Having found the Points *m* and *k*, both denoting the upper Part of the Facies, if you lay a Ruler to theſe two Points, and continue a ſtrait Line till it cuts the Horizontal-line *x*, *y*, as at *ſ*, that ſhall be the accidental Point, (or, as the Draughts-Men ſometimes call it, the vaniſhing Point,) which being found, you may from thence draw right Lines to any other Points on the Draught which were viewed obliquely from *z*; (and therefore the Figures on that Part of the Building muſt be made inclined on the Draught,) and thereby find the Abridgment of all the Lines parallel to the Horizon on the Building or geometrical Plan; (which is ſuppoſed parallel to the perſpective Plan or Picture)

So when you have protracted the vertical Angles of 4, 3, 2, 1, *Fig.* 33. and thereby found thoſe Points. You may lay a Ruler to each of them, and the accidental Point *ſ*, and thereby draw the Facies on the Wings of the Building according to their Breadth and Diſtance from one another on the perſpective Plane or Draught.

In like Manner having found the Points *e*, *i*, and *u* of the firſt Window, you may from *e* and *i*, draw Lines to the accidental Point *ſ*, which will give the Bottoms and Tops of all that Row: And then you have nothing to do, but find their Breadth and Diſtance; and by theſe Directions draw all the Windows on that Wing of the Building.

If a Statue, Coat of Arms, or other Object was placed at *o*, *Fig.* 33. and it was deſir'd to place the ſame (or another,) a good Deal higher, as at *r*; but ſo, that the Object when placed at *r* ſhould appear full as big, as when at *o*; being viewed from *z*.

Obſerve with the Theodolite, the Angles under which the Object appears at *o*, as if it was a Statue, obſerve the Height from the Feet to the Head, *&c.* and note the Angles with proper Remarks on a piece of Paper; and then by directing the Telleſcope to *r*, and ſetting the Quadrant and Index to the ſame Angles, you may give Directions how to make the Object at *r*, of ſuch Dimenſions as being viewed from *z*, will appear of the ſame Magnitude (or natural Height) with that at *o*; *& vice verſa.*

The ſame may be done, if Objects are deſired to be placed at a Diſtance, to appear of the ſame Size as thoſe that are nearer; with ſeveral other Problems to be performed by this Inſtrument, which the Ingenious will find out in the Uſe thereof: But I have already exceeded what I intended on this Head, and ſhall only add two or three Aſtronomical Problems, which the Surveyor perhaps may find very uſeful in Practice.

CHAP. III.

PROBLEM I.

How to find a True Meridian-Line, by Obſerving with the Theodolite.

THE beſt Time to make the Obſervations, are in a clear Day, about 3 or 4 Hours before and after Noon.

In the Morning, having ſet the Inſtrument exactly level, move the Index Horizontally, and the Quadrant Vertically, till through the Telleſcope you ſee the croſs Hairs in the Center of the Sun: Then obſerve what Degrees and Minutes are cut by the Index, ſuppoſe 3°, 25', which note in a Piece of Paper, as alſo the Angle of Elevation cut by the Quadrant.

About ſo many Hours after Noon, obſerve exactly, that the Quadrant be ſet to the ſame Angle of Elevation as in the Morning; and then move the Index on the Limb till you ſee the croſs Hairs cut the Center of the Sun, as in the Morning; and note the Degrees and Minutes which the Index then cuts on the Limb, ſuppoſe 64°, 37'.

But Note, 'tis convenient in the Morning to make 3 or 4 Obſervations 5 or 6 Minutes from one another; becauſe in the Afternoon you muſt wait till the Sun falls into the ſame Altitude as it had when you made the Obſervation in the Morning, (the Quadrant remaining at the ſame Angle at both;) and if it ſhould happen to be obſcured by Clouds at that Inſtant, your Labour will be loſt for that Day, having made but one Obſervation in the Morning.

Now, if from 64°, 37′, the Evening Obſervation on the Limb, you ſubtract 3°, 25′, the Morning Obſervation, the Remainder will be 61°, 12′, the half of which is 30°, 36′; to this half Sum 30°, 36′, add the Morning Obſervation 3°, 25′, and the Sum will be 34°, 1′.

Laſtly, the Inſtrument remaining in the ſame Poſition, bring the Index on the Limb to 34°, 1′, and the Quadrant and Telleſcope will be exactly in the Plane of the Meridian: But if the Obſervation on the Limb in the Morning, exceed that in the Afternoon, you muſt add to the Afternoon Obſervation 360, and work in like Manner; and if the Remainder ſhould exceed 360, you muſt ſubtract 360 therefrom.

Now obſerve what Point (on ſome firm Wall of a Building) is cut by the croſs Hairs in the Telleſcope, there cauſe a good Mark to be fixed, or cauſe a Pillar with a Mark thereon to be ſet up by the Direction of the Telleſcope: Alſo take Notice, If you could place the Mark a Quarter or Half a Mile diſtant from the Inſtrument, it is better than if it was nearer. And in making theſe Obſervations, you ought to be very exact; becauſe when a Meridian-Line is once well fixed, it is very uſeful for divers Purpoſes.

Obſerve, When the Sun is near the Tropicks, the Meridian-line may be found well enough by obſerving as aforeſaid: But when it is near the Equinox, there will be ſome Variation; becauſe the Sun's Declination is greater or leſs at different Times in the ſame Day: And conſequently when in equal Altitudes, has different Azimuths. Therefore the Meridian-line may be more truly found, By the *Pole Star*.

The following Table ſhews the Time from Noon, when the Pole Star *makes the greateſt Angle from the Meridian-Line towards the Eaſt, for any Time in the Year.*

January.			*February.*			*March.*			*April.*		
D.	H.	M.	D.	H.	M.	D.	H.	M.	D.	H.	M.
1	23	16	5	20	52	5	19	8	2	17	27
8	22	51	12	20	26	12	18	43	9	17	0
15	22	17	19	19	59	19	18	17	16	16	35
22	21	48	26	19	33	26	17	52	23	16	7
29	21	20							30	15	40
May.			*June.*			*July.*			*Auguſt.*		
7	15	13	4	13	19	2	11	23	6	9	6
14	14	45	11	12	49	9	10	55	13	8	40
21	14	16	18	12	20	16	10	26	20	8	14
28	13	48	25	11	52	23	9	59	27	7	50
						30	9	33			
September.			*October.*			*November.*			*December.*		
3	7	23	1	5	42	5	3	26	3	1	26
10	6	58	8	5	16	12	2	57	10	0	54
17	6	32	15	4	50	19	2	27	17	0	24
24	6	8	22	4	22	26	1	57	24	23	53
			29	3	54				31	23	23

And, to find the Time that the Pole Star will make the greateſt Angle on the Weſt of the Meridian; add 11 h. 84 m. to the Time found in the Table: Alſo *Note,* The Star comes to the ſame Place about 4 Minutes ſooner every 24 Hours, than it did the Day before.

The following Table ſhews the greateſt Angle which the Pole Star *makes with the Meridian in any of theſe Latitudes*, (viz.)

Latitude.		*Angles.*	
Deg.	*Min.*	*Deg.*	*Min.*
49	00	3	53
49	30	3	55
50	00	3	57
50	30	4	00
51	00	4	03
51	32	4	6
52	00	4	9
52	30	4	12
53	00	4	15
53	30	4	18
54	00	4	21
54	30	4	24
55	00	4	27
55	30	4	30
56	00	4	34

The Time that the Pole Star comes to the Eaſt or Weſt of the Meridian, and the greateſt Angle which it makes therewith, being found by the preceding Table: Set the Theodolite horizontal, and bring the Index to 360 on the Limb; then turn the whole Inſtrument about, and elevate or depreſs the Telleſcope, till you ſee the Pole Star in the Interſection of the Hairs therein, and there ſcrew the Inſtrument faſt: Then (if the Obſervation was made in the Latitude of *London*, 51°, 32′) move the Index on the Limb 4°, 6′, (as by the Table) towards the Right Hand or Left, according as the Star is Weſtward or Eaſtward: And the Telleſcope will be ſet exactly in the Plane of the Meridian.

PROBLEM 2.

How to find the Latitude of any Place, by the Theodolite.

THE Inſtrument being ſet level, bring the Quadrant and Telleſcope into the Plane of the Meridian, and let the Index remain at the ſame Angle on the Limb; then elevate or depreſs the Telleſcope towards the Sun, at ſuch Time as you think it is near the Meridian, until you ſee the croſs Hairs in the Center thereof, dividing it as it were into four equal Quarters; and obſerve exactly what Degrees and Minutes are then cut on the Quadrant, ſuppoſe 42°, 15′, which note for the Sun's Meridian Altitude.

By an Ephemeris, you may find the Sun's Declination for the ſame Day, ſuppoſe 3°, 47′, which if it be North Declination, ſubtract it from 42°, 15′, the Meridian Altitude, and the Remainder will be 38°, 28′, the Co-latitude.

But if the Sun hath South Declination, add it to the Meridian Altitude, and the Sum will be the Co-latitude; which ſubtracted from 90°, gives the Latitude of the Place.

PROBLEM 3.

How to find when the Sun or any of the Stars are upon the Meridian: And the exact Limits of the Natural Day.

HAving the Co-latitude of the Place, by the laſt Problem, and the Declination of the Sun given; add the Declination, if North, to the Co-latitude; but if South, ſubtract it, and the Remainder will be the Sun's Meridian Altitude for the Day, as aforeſaid, which ſuppoſe to be 42°, 15′.

Set the Quadrant to 42°, 15′, and the Telleſcope will be elevated to the Meridian Altitude of the Sun; then note the Inſtant of Time by a Watch or Pendulum-Clock, when through the Telleſcope (remaining at the ſame Angle) you ſee the croſs Hairs cut the Center of the Sun; for at that Time is the Sun upon the Meridian.

And if you proceed in like Manner the next Day, you will have the exact Limits of the Natural Day, which muſt exceed or want ſo many Seconds of 24 Hours, by your Clock or Watch, as appears by the Equation-Table for the Day, if your Clock or Watch goes right.

In the ſame Manner, you may obſerve when any Star comes to the Meridian; and if the ſame Star comes to the Meridian 3 Minutes, *56* Seconds and a half, ſooner the ſecond Night than it did the firſt, your Pendulum-Clock or Watch keeps true Time, *& è contra.* Alſo if you ſubtract 3 Minutes, *56* Seconds and a half, for each Night after that on which you made the firſt Obſervation, you will have the true Time of that Star's coming to the Meridian for each Night following.

And thus may a Pendulum-Clock or Watch be adjuſted to the Mean Motion of the Sun.

PROB.

PROBLEM 4.

How the Azimuth and Altitude of any of the fixed Stars are found by the Theodolite.

THE Inſtrument being ſet level, and exactly in the Plane of the Meridian, and there fixed, if you direct the Telleſcope to any Star, its Azimuth is ſhewn by the Index on the Limb; and the Altitude by the Quadrant both at the ſame Time.

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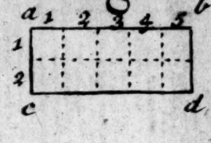

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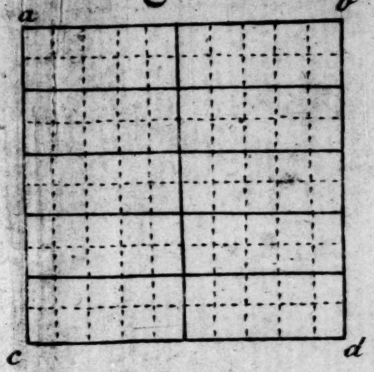

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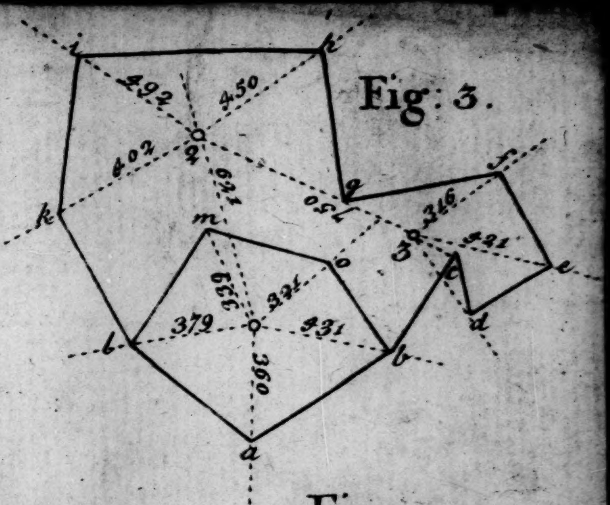

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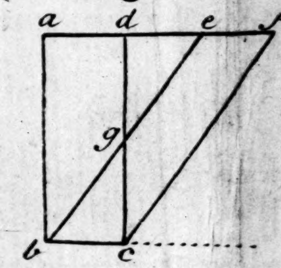

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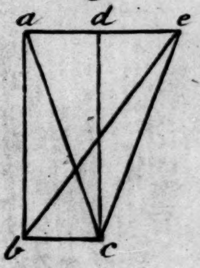

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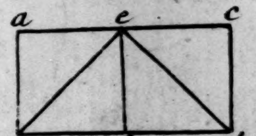

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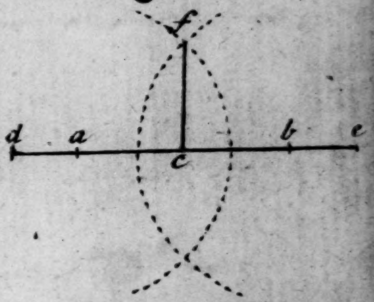

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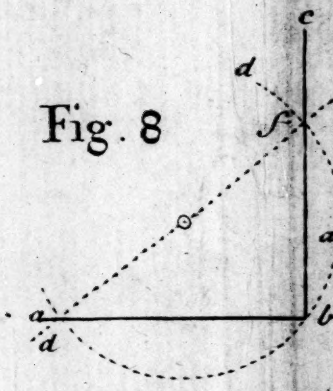

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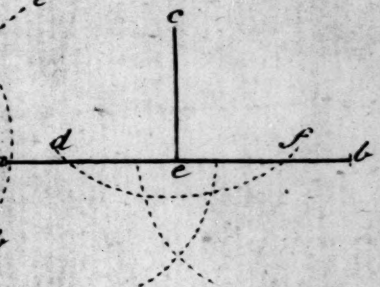

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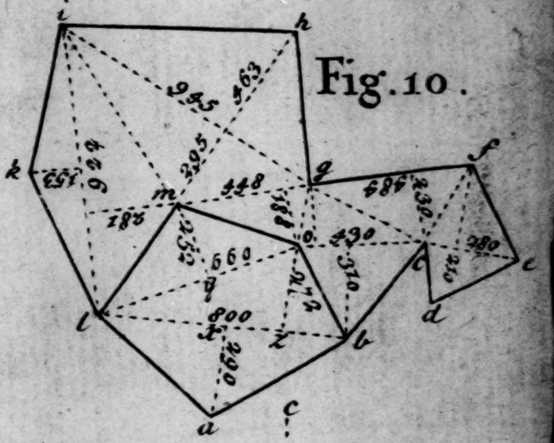

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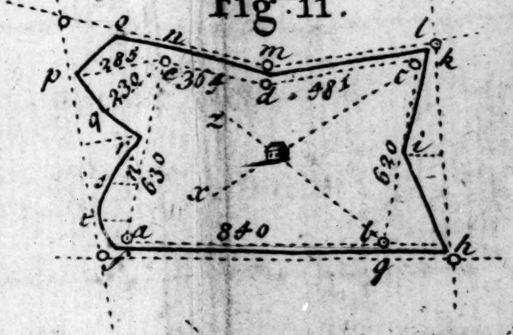

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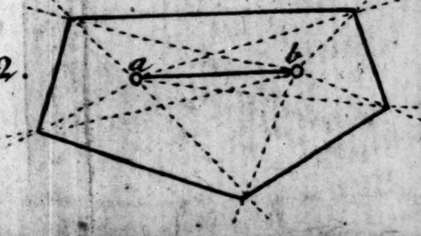

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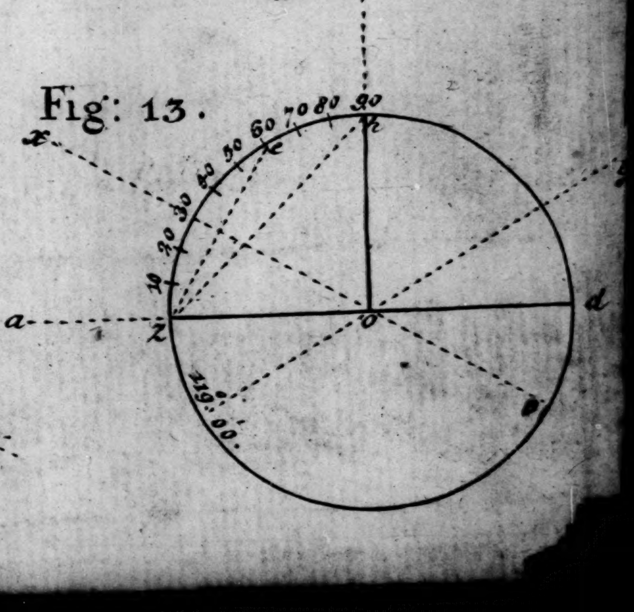

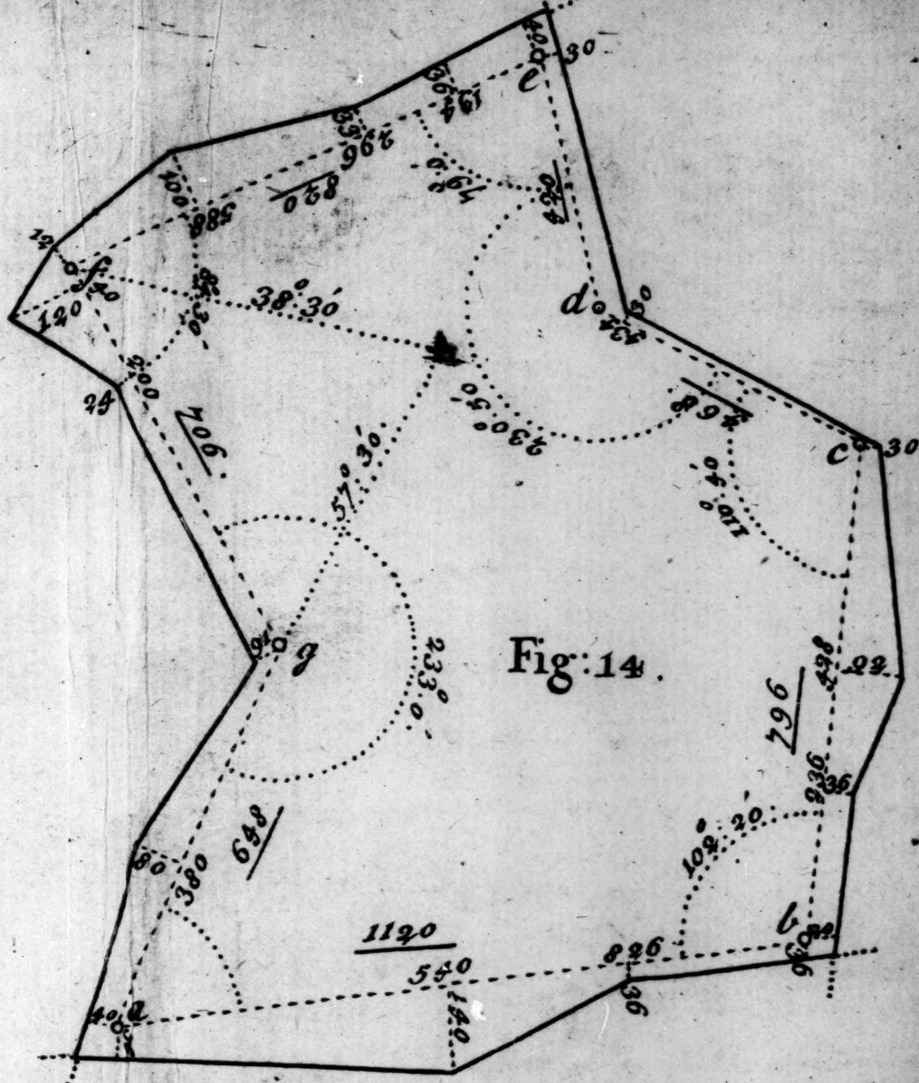

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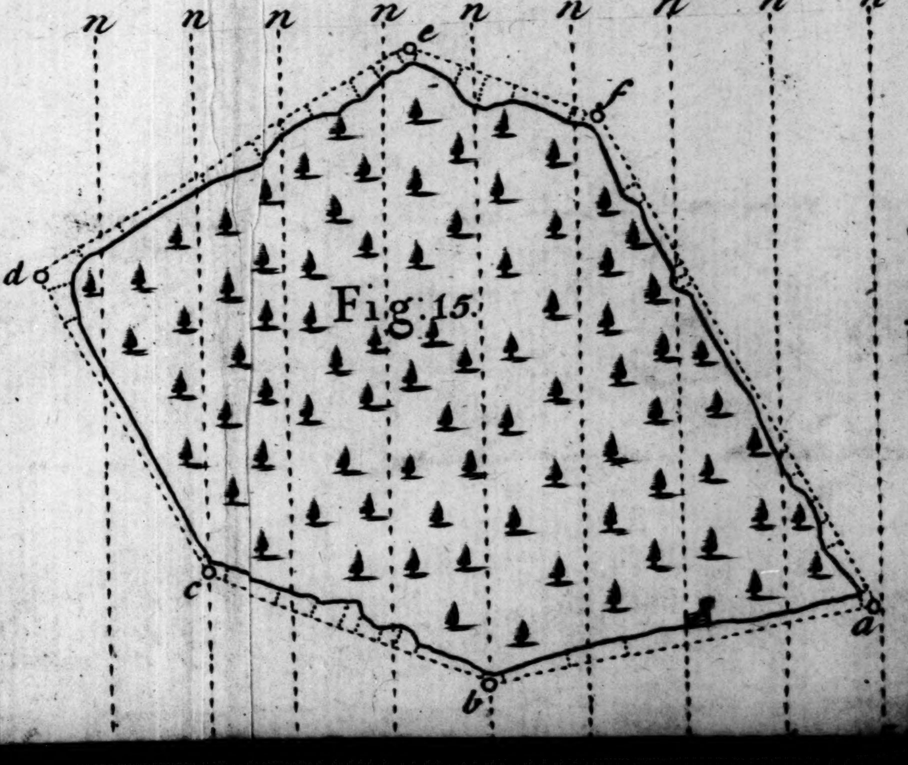

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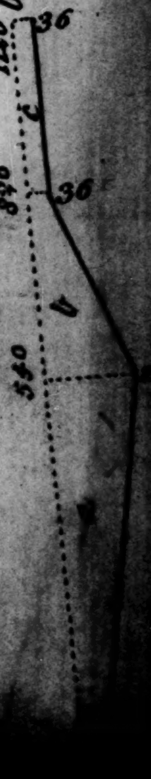

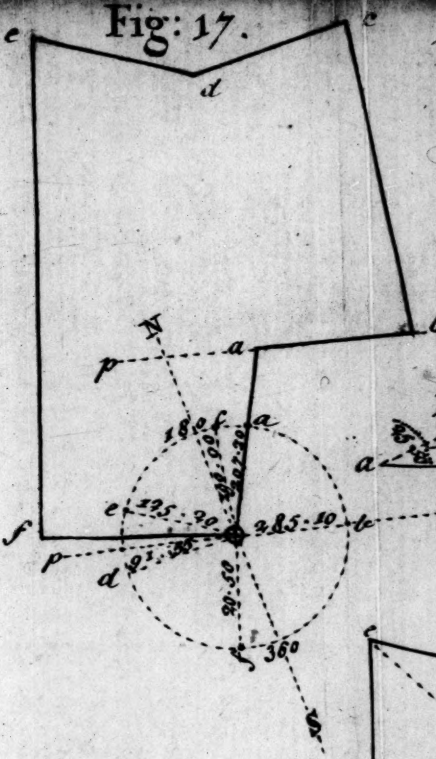
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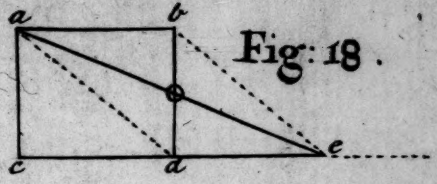
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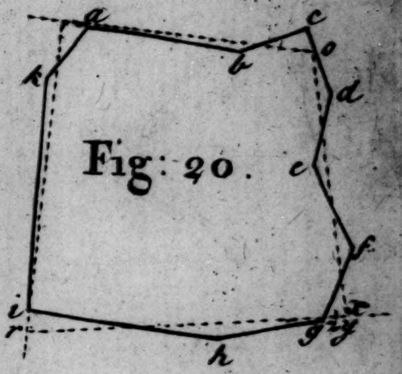
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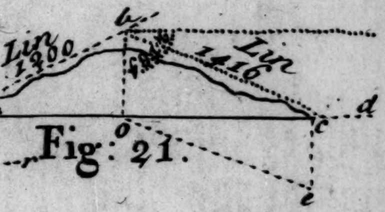
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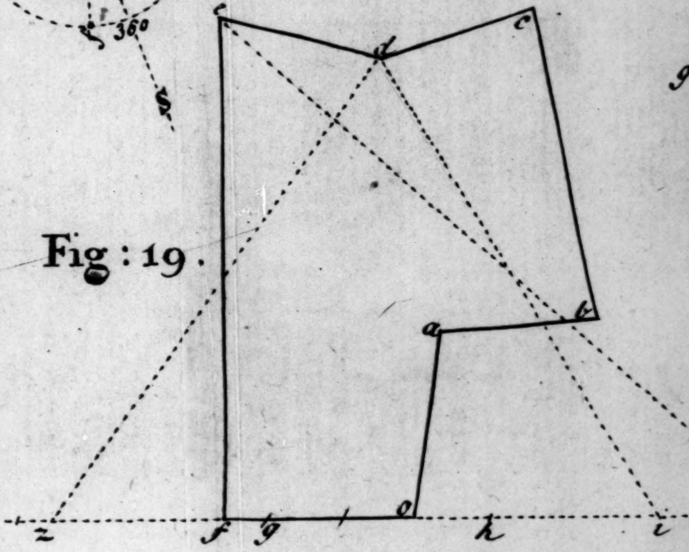
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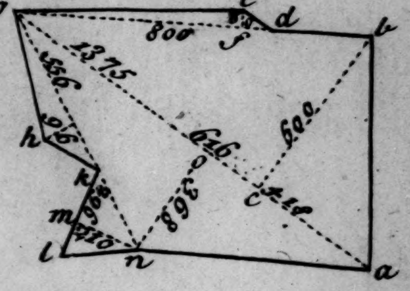
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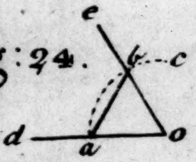
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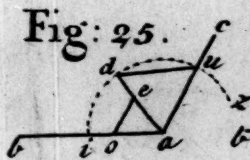
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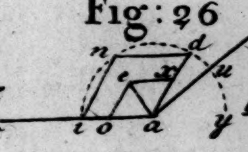
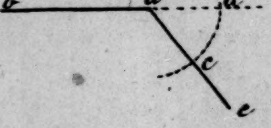


Fig: 26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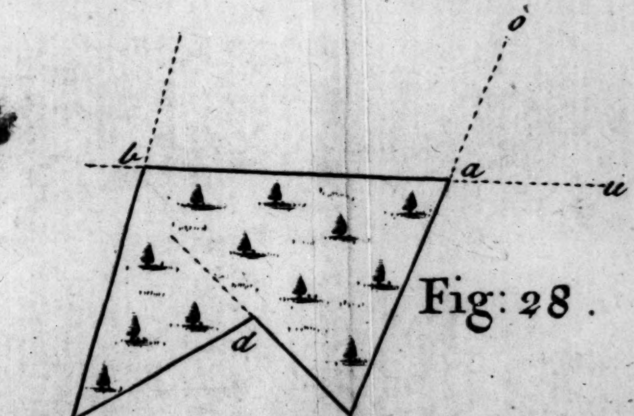
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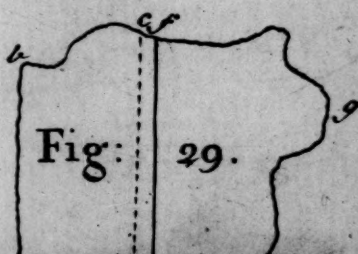
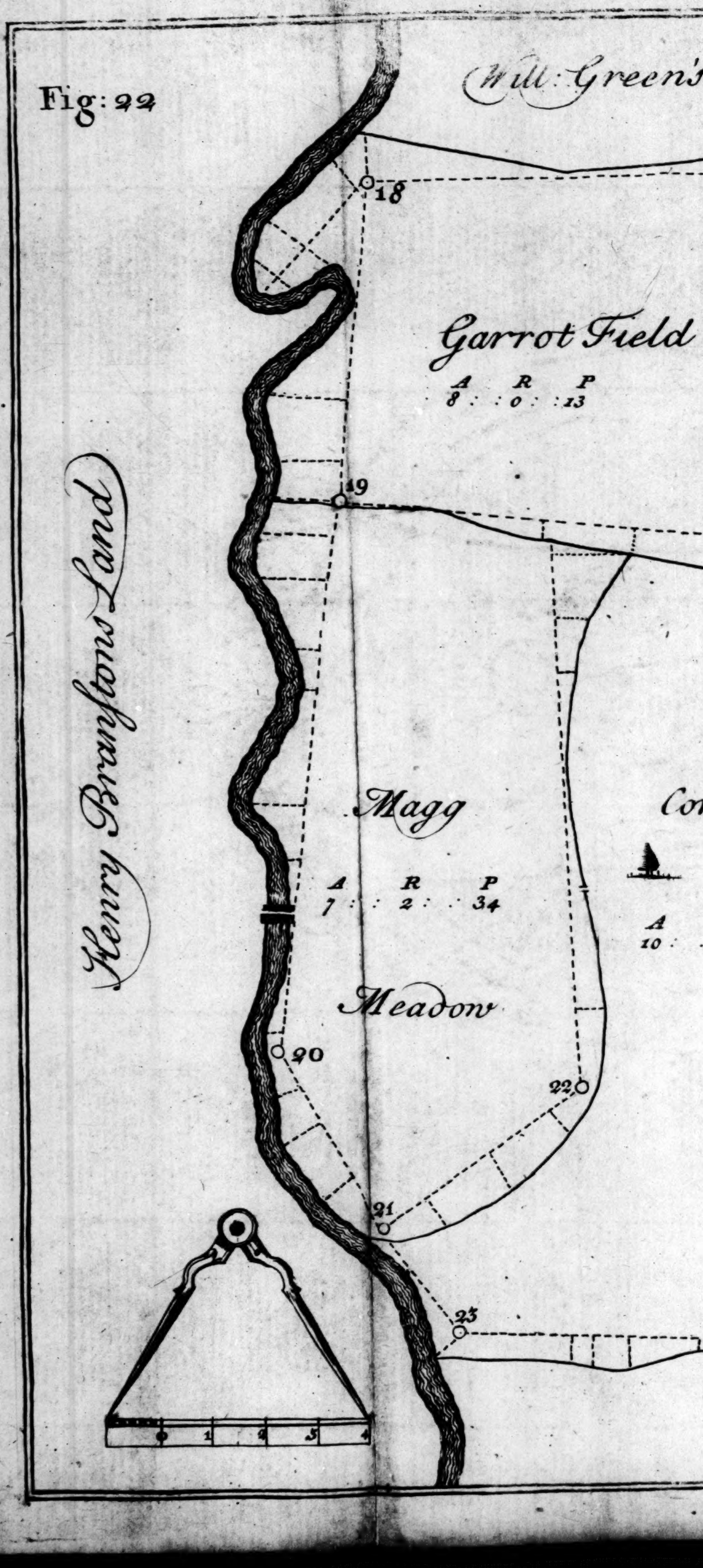


Fig: 29.

Fig: 22


Will: Green's
Garrot Field
A R P
8 : 0 : 13
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Henry Branstons Land
Magg
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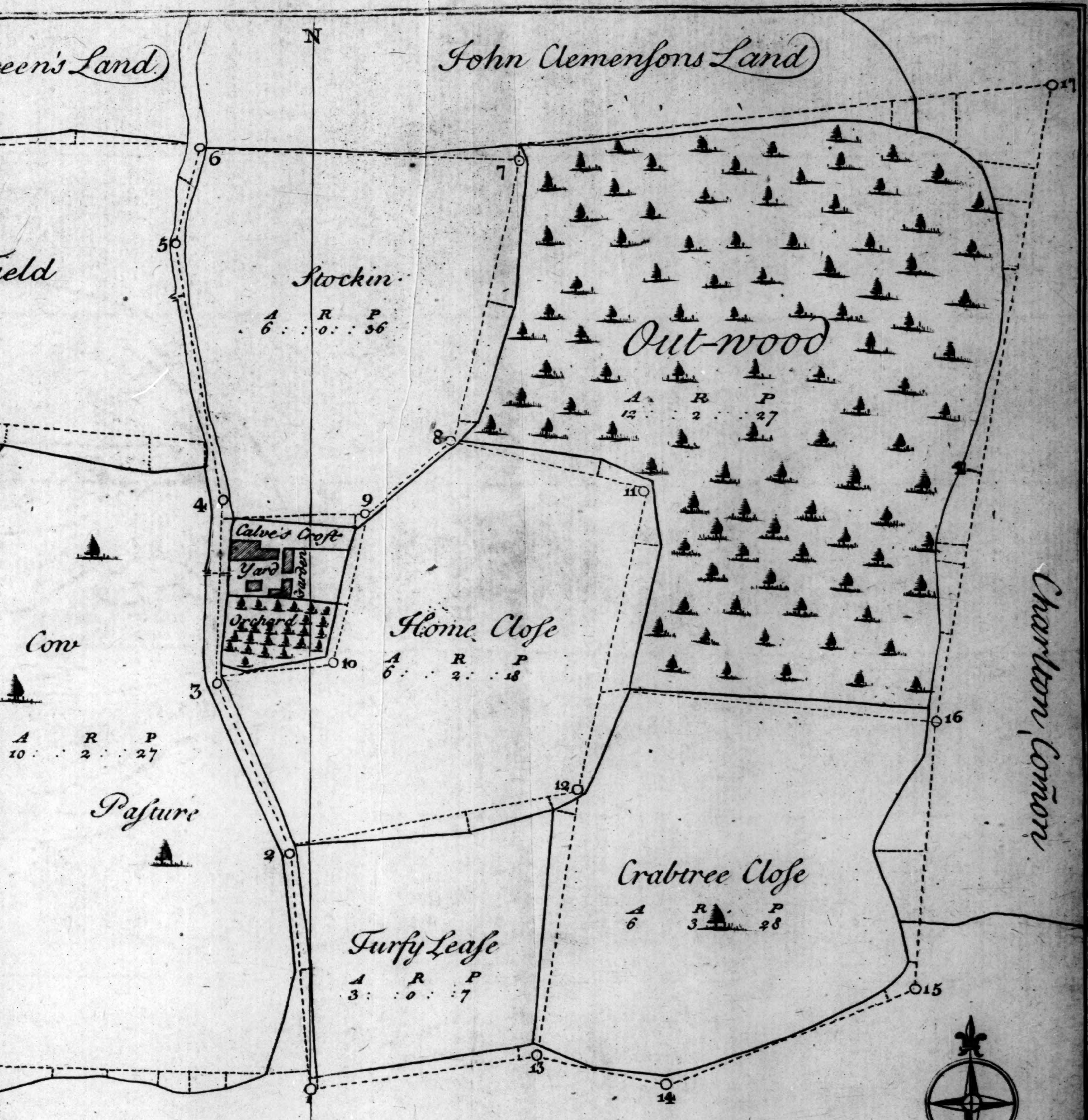
een's Land
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Cow
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Paſture
Crabtree Cloſe
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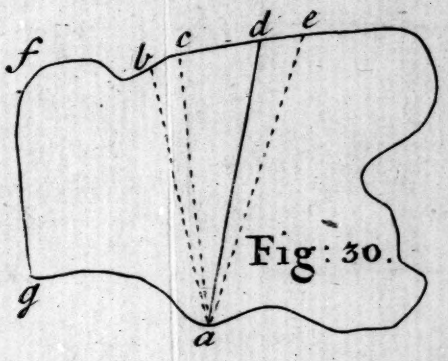

Fig: 30.

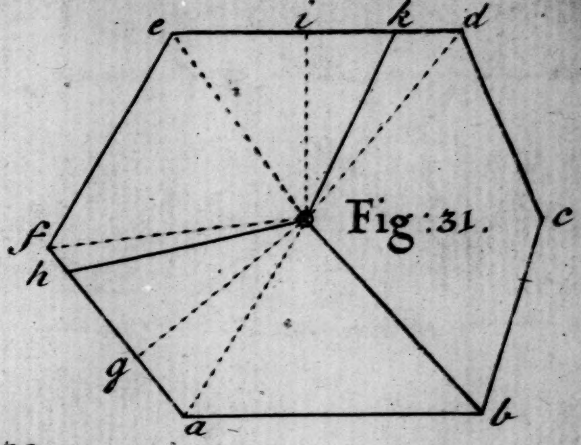

Fig: 31.

Fig: 32.

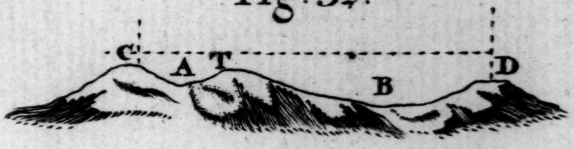

Fig: 33